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STUDIES IN EARLY PETROLEUM HISTORY

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THE HISTORY AND POLITICS OF OIL

HYPERION PRESS, INC.

Westport, Connecticut

Samarra-type cobalt painted pottery bowl of the ninth century A.D. believed to represent a fire temple (Museum Teheran).

STUDIES IN EARLY PETROLEUM HISTORY

BY

R. J. FORBES

WITH 16 PLATES AND 32 FIGURES

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E. J. BRILL
1958

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INTRODUCTION

Habent sua fata bituminae

Bitumen and petroleum played but a minor part in the classical world[1]. Wood-tar and pitch took their place. However, in the Near East the ancient Mesopotamian traditions and practical experience survived though they enjoyed a temporary eclipse. After the Persian Empire we find few data on the history of petroleum until we reach the days of the expansion of the Islam. Arab authors such as Ibn Hauqal[2], Al-Muqadassi[3], Al-Qazwînî[4], Ibn Jubair[5] and many others wrote many passages showing that the ancient seepages of the Near East were not forgotten but were regularly exploited and that new ones such as those of Baku more fully investigated.

We find that crude oil was produced on such a scale that the discussion of the legal side of mining concessions formed an important subject in Arab law. Of old the sultans had been considered to own all "non-exposed" minerals such as gold, silver and copper. The Arab lawyers of the tenth and eleventh centuries after a lengthy discussion decided that this held also for the "exposed" minerals such as petroleum and bitumen, gathered at the earth's surface or at shallow depths and that the sultans could allot concessions to other subjects. Theories on the origin of petroleum were often taken from classical authors such as Aristotle but some authors like Muwaffak[6] considered petroleum to be a kind of "coagulated dew" with a high "air- and sulphur-"content.

The different forms of distillation apparatus had been developed in the Near East (first in Alexandría, then in Syria) in the course of the early centuries of our era[7]. Arab authors like Al-Qazwînî[8], Alnabarawi, Ibn Al-Baiṭâr[9]

[1] R. J. Forbes, Bitumen and petroleum in Antiquity (Studies in Ancient Technology vol. I, Brill, Leiden, 1955).

[2] Ibn Hauqal, Travels (edit. De Goeje, Bibl. geogr. arab. II, Leiden, 1873).

[3] Al-Muqadassi, Ahsan al-taqâsîm (edit. De Goeje, Bibl. geogr. arab. III, Leiden, 1877).

[4] Al-Qazwînî, Kosmographie (edit. Ethé, Leipzig, 1868).

[5] Ibn Jubair, The travels of . . . (Rahlat-al-Kînânî) (edit. De Goeje, Gibb Memorial Series vol. 5, Leiden, 1907).

[6] Abu Manṣûr Muwaffak, Das Buch der pharmakologischen Grundsätze (edit. Achundow, Halle, 1893).

[7] R. J. Forbes, Short History of the Art of Distillation (Brill, Leiden, 1950).

[8] J. Ruska, Das Steinbuch aus der Kosmographie des al-Kazwînî (Beilage Jahresber. 1895/96 prov. Oberealschule Heidelberg).

[9] Ibn Al-Baiṭâr, Traité des Simples (edit. Lucien Leclerc, Paris, 3 vols., 1877 & 1883).

Ibn Al-Awwâm, Dimashqî[1] and others inform us that large quantities of light distillates ("naft") were produced in such centres as Damascus to be used for lighting, cleaning silk and other textiles and for war purposes. Other bituminous substances such as rock-asphalt were sometimes submitted to "destillatio per descensum" (a combination of smelting and cracking) to produced oils for lighting and lubrication.

Naft was extensively used by the Arab and Mongol armies for grenades, flame throwers and other war engines. Not only are we informed that Persian and Syrian oil were imported into Egypt for the torches of the Sultan's body-guard. When Cairo was evacuated and destroyed in 1077 as the Crusaders approached the conflagration was fed with the "naft" from 20,000 pottery jars and flasks, which means about 200 Tons of gasoline were stored in the arsenal! The special asbestos-clad "naffatyn" handling such inflammable materials always formed part of the parades of the Arab armies and demonstrated their skill to the delight of the spectators. Thus Abd Al-Latîf of Baghdad tells us that such a parade was held at Baghdad in 1228[2] "during which parade many soldiers played with glass balls filled with naft which they threw about them so that the steppe was filled with fire". Greek Fire played a large part in the Byzantine and Arab armies and its use often turned the scale. In 846 the town of Heraclea immediately surrendered to Harûn Al-Rashîd[3] "when the inhabitants marveled at the large machines throwing burning naphtha".

Not only did the Crusaders and other European travellers such as Marco Polo bring back stories about the gas wells and oil seepages of the East and the use of naft and Greek Fire, but in the West the old traditions and knowledge of petroleum and bitumen did survive through the ages. This was particularly true of their application in medicine, pharmacy and agriculture. The medieval medical and pharmacological handbooks faithfully repeat the classical and Arab data on the virtues of petroleum and bitumen. These data are used in the pamphlets propagating the sale of the crudes which several Western nations gradually started to collect locally.

The story of these European seepages is but partly known, most of the information is still buried in local archives. We do know, however, that several seepages were discovered and exploited. Apart from the medicinal use of petroleum it was applied for lighting and lubrication locally. Few new uses were found in the course of the centuries. The eighteenth century saw the

[1] Mehren, Manuel de la Cosmographie du Moyen Age (translation of Dimashqî) (Kopenhagen, 1874, pp. 69-97, 153).

[2] v. Somogyi, Islam vol. 24, 1937, p. 119.

[3] Ibn Khordabeh, Livre des Routes (edit. De Goeje, Leiden, 1884, p. 73).

rediscovery of bitumen and rock-asphalt. The pioneers in their fervour propagated these products for applications which were soon forgotten but they laid the foundations for the modern use of asphaltic bitumen and they started the revolution in road transport heralded by the asphalt road. This development of the petroleum industry during the Middle Ages and later centuries up to the rise of the modern phase in the days of Drake is worth studying. What the following chapters sketch is but the bare outline and many points are still far from clear.

CHAPTER ONE

THE „FONT DE L'OLI" AT GABIAN

Between Béziers and Montpellier, near Gabian, there lies one of the oilfields where a small proportion of the national oil consumption is obtained from French territory. Modern exploitation began on 20th August, 1924, and up till June 1929 a total of about 15,000 tons was produced, i.e. about 3000 tons per annum, a quantity which subsequently fell to 2000 tons per year and soon declined even further owing to the limited extent of the oil-bearing layers. Gabian crude is dark brown in colour and, owing to the high paraffin wax content (about 10½%), is of a pasty consistency. It contains practically no low boiling-point components and has a low sulphur content[1].

Although Gabian crude plays no part in world petroleum economy, nor even in that of France, it certainly did so in the history of petroleum. It is well-known that petroleum, in spite of the recommendations of such pioneers as Georg Agricola (1555) or Johann Volcken (1625), was almost exclusively used for medicinal purposes apart from local use as a lubricant or source of illumination[2]. For instance, the oil seepages at Wietze (Hanover), Tegernsee (Bavaria), Lampertsloch (Hanau) and Monte Zibio (Modena) were widely known round about 1500, the latter through a pamphlet purporting to be written by a Dr. Francesco Ariosto in 1460 in Modena, but which was only published much later in a revised form.

In his pamphlet, this same Dr. Ariosto mentioned the oil source situated in the valley of the Tongue, 1500 metres to the south of the village of Gabian, which source was equipped and operated for medicinal purposes during the 18th century by the monks of Casan. The examination of a sample taken from

[1] Petroleum Times, 1929 p. 774-775
Oil News, 1929 200-201
Oil News, 1926 488 & 494
Revue Pétrolifère No. 172, 1926 13-19
„ „ No. 132, 1925 3
„ „ No. 255, 1928 137-146
Petroleum Times, 1926 823-825.

[2] R. J. Forbes, Advertising Crude Oil Four Hundred Years Ago (De Ingenieur, Petroleumnummer, June 1951, pages 1-3).

this well between 1800 and 1830 shows that the oil was less waxy than the oil from modern bore-holes, but that it was heavier. Here again, only a few low boiling-point components were found. It is not quite clear when the exploitation of the oil well at Gabian was begun, but it must have been in the 17th century or even earlier.

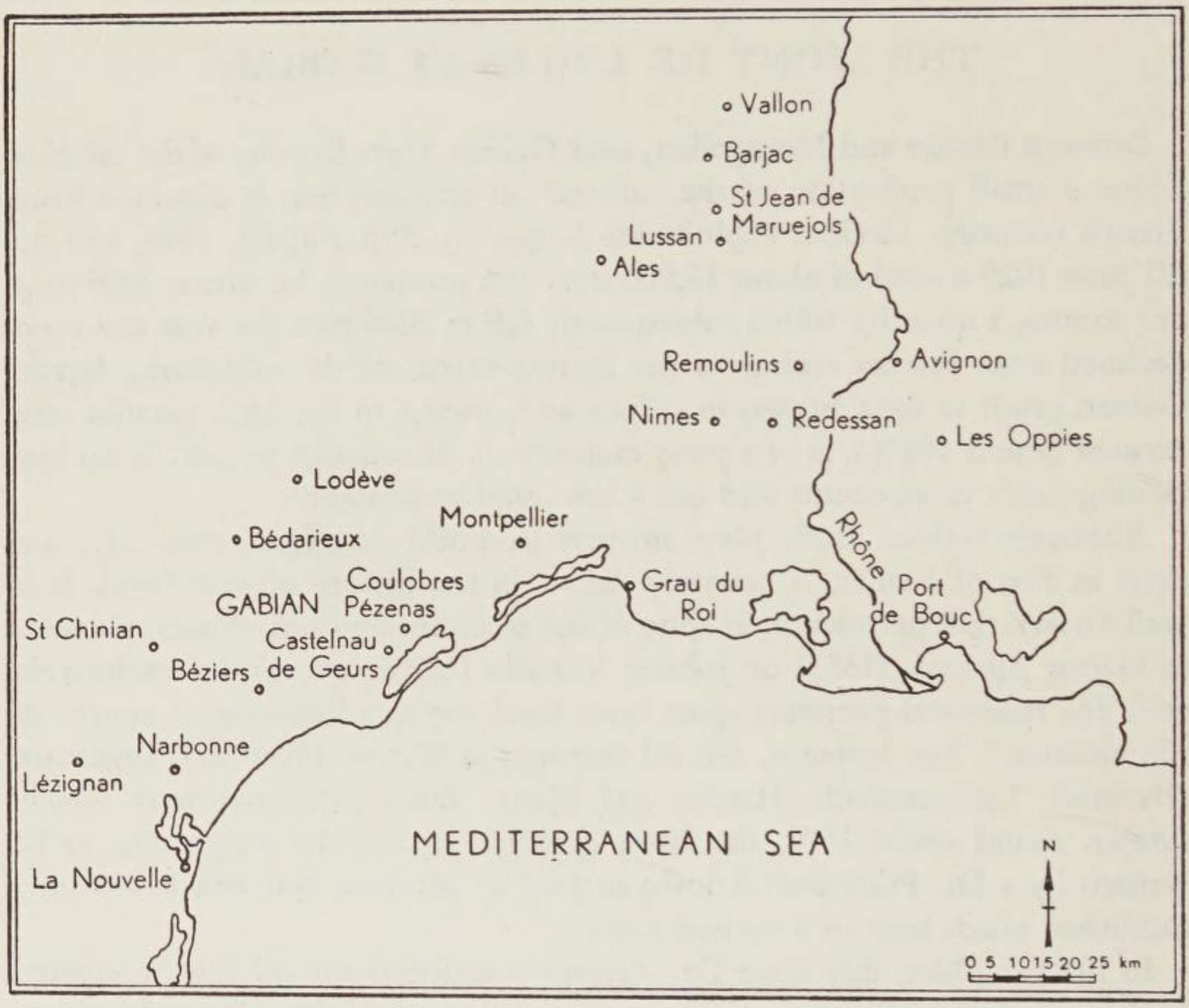


Fig. 1. Map of the Gabian region.

In 1694 Pomet, a famous pharmacist and spice-dealer, author of a well-known pharmaceutical handbook[1] mentioned that the "huile de petrolle de Gabian" had already been collected for many years, though by his time the flow of oil had greatly diminished:

"The Petroleum or black oil of Gabian is a liquid bitumen which comes out of the depths of the earth, which passes along underground channels and reaches the surface of a small stream near a little village known as Gabian,

[1] Pierre Pomet, Histoire générale des drogues . . . (Loyson et Pillon, Paris, 1694, Pars III, Lib. iii, cap. XVII).

situated in the Bishopric of Béziers in Languedoc. This oil was formerly so abundant and copious that it was not highly valued, and a fairly large amount could be collected every day, but nowadays it is collected only on Mondays, and the place where it accumulates is surrounded by walls and guarded. I was assured at Gabian that the Bishop of Béziers obtained a large income from it, though not so large as it used to be.

This oil must be of medium consistency, with a strong unpleasant smell, and black in colour.

Care should be taken to see that this is not thick turpentine oil coloured with pitch-pine and black pitch, and the best advice I can give, is to buy it from honest merchants who are incapable of selling you the one for the other, and not to pay too much attention to cheapness."

As early as 1717, a certain Dr. Rivière had published a detailed survey in the Transactions of the Academy of Montpellier, the famous university town, which was not far from Gabian and where for centuries there had been much interest in the use of natural resources. According to Ariosto the source at Gabian was discovered in 1608, and apparently the exploitation of the well was a not unimportant source of income for the bishop of Béziers, since trade in the product extended far beyond the borders of France. This can be seen by reading further in the pamphlet, when the following passage appears:

"This source was previously much greater, if it is true, as M. Rivière states, that the Petroleum obtained for more than 80 years amounted to 36 quintals every year. However, since it still produces three or four quintals of oil (300-400 litres) every year, and since the maladies for which it is used are not everyday ones, enough is obtained to supply the foreigners who ask for it in Paris. Not long ago several containers were sent to Holland, Germany and America".

Rivière's article was published as a booklet and had soon become difficult to obtain, but the author had never undertaken a reprint. In 1752, however, there appeared an extensive pamphlet on the subject of Gabian oil, which was based on a lecture given at Béziers, and was printed on account of its detailed description of the nature and application of this oil, being an excellent manual for the stimulation of consumption. The title is:

REPORT ON PETROLEUM IN GENERAL AND THAT OF GABIAN IN PARTICULAR

Read at the Academy of Sciences and Fine Arts of Béziers, approved by the University of Medicine of Montpellier, and printed by order of M. De Bausset de Roquefort, bishop and lord of Béziers (Béziers, Barbut, 1752).

The writer, who remains anonymous, remarks that Dr. Rivière's pamphlet is no longer obtainable, and that moreover the latter did not go deep enough into the way in which Petroleum Oil should be applied, and when it is desirable or perhaps dangerous to use it. At the same time, he tells us:

"Since this oily Liquid has ceased to flow for some years owing to the fact that the Fountain which supplies it has not had the necessary repairs carried out, it is advisable to inform the Public that this mineral Balsam has now been flowing for some time in sufficient quantities to supply not only the whole of the Kingdom but also foreign Countries, as a result of the repairs effected on this fountain at the expense of M. De Bausset de Roquefort, Bishop of Béziers, Lord of Gabian. Finally, it was thought that the Public should be informed of the wise precautions taken by this zealous Prelate for the benefit of Invalids, to ensure that henceforth this Remedy is not falsified. These precautions consist in having the Oil collected by a Person of proved loyalty, who has been commanded to put it into Bottles of varying sizes, to seal these Bottles with the Seal of his coat of Arms, and to sign the Label which is placed thereon; with the result that the public is now assured of having pure Petroleum Oil, just as it flows naturally from the source."

First, there is a discussion of the chemical properties of the Gabian oil, as they were defined by the knowledge and methods of the time:

"The Academician of Montpellier (M. Rivière) remarks in the first place that the Petroleum Oil is opaque, and dark red-brown in colour: that it is inflammable, and that these two latter qualities mean that this Oil should be classified as a liquid bitumen.

He then makes the following remarks, which had been communicated to the Académie Royale des Sciences (of Paris) by Marius, a physician:

1. A candle manufactured out of equal parts of resin and this Petroleum Oil burns in water and is consumed right up to the end.
2. The vapour which rises when this oil is burned ignites three feet up if a candle is brought near, or better still a sulphur match.
3. Water does not extinguish the Oil once it is ignited, but makes it rise up with some noise; and wood, wicks, matches, etc. burn in this oil when mixed with water, until the Oil is entirely consumed.
4. This Oil does not become thick in frosty weather, like ordinary oil[a].
5. Petroleum Oil is lighter than Olive Oil by 18 grains per ounce, than Brandy by thirty, and than ordinary Water by eighty-four.
6. It sinks more rapidly into water than other Oils, but rises more quickly, particularly if it is refined.

[a] This remark, which we have repeated this year, shows an easy method of distinguishing by means of Remark 5, as we ourselves have proved.

7. A single drop of this Oil poured on the surface of still water will soon cover an area with a diameter of one fathom, and will form very bright colours; and if it spreads further, it becomes white and finally disappears.

M. Rivière adds his own Experiments to these Remarks, which lead him to believe that Gabian Oil is the same as that obtained about half-way through the distillation process of Amber; and by chemical analysis he finds that the Gabian and Amber oils show traces of a latent volatile acid salt, and that they also contain a volatile alkaline Salt, which is similar to Marne Salt or to the urinous part of sal ammoniac. This alkaline salt is enveloped and so to speak bound up with the Petroleum, apparently by the terrestrial part of this Oil, and it appears in the first portion which comes from distillation over low heat, and also in its scum, and in Amber Oil. He concludes from this that Petroleum is a sort of Amber which has remained liquid owing to not having encountered some kind of sap which would coagulate and harden it, or which has become liquid as a result of dissolution by acrid salts, and which has been carried away by mineral Water[b], adding that it was for this reason that *Paracelsus* called this strong oil, *Succinum resolutum*."

The author then states that no conclusive proof has as yet been provided:

"M. Rivière could have tested whether the residue at the bottom of the retort after distillation of the Petroleum over a gentle flame attracts straws as does Amber; but although he has not done it, Ramazzini (*Epist. de oleo montis Zibinii 1698*), says that he has, and that he realized that this residue which is black like pitch has no electrical properties; in so saying, he contradicts Oligerus Jacoboeus (V. Proef ad Epist. F. Ariosti. Published at Haff. 1690) who claimed to have found this property in it.

After discussing the nature of Petroleum, M. Rivière gives a brief summary of the principal properties of this mineral liquid. But before turning to this subject, we shall no doubt be allowed to summarise what other writers have said about it.

Among modern writers who have discussed Petroleum, there is no one earlier, that I know of, than François Ariosto, who in a letter written to Prince Borsius, Duke of Regio and Modena etc., in 1460, which was not printed until 1690, put forward various theories about the nature of this Oil, and discoursed at length about its virtues.

Some, he says, think that Petroleum is similar to the clear Liquid Asphalt

[b] The Oil does not flow of its own accord; it is brought by underground pipes, together with the water on which it is floating, into a pool inside a building, where it remains continually on the surface of the water without ever becoming mixed with it. The Oil collects in this pool, and the water is separated from it by means of a drain-cock which carries it to an aqueduct, from where it runs into a nearby stream (M. Rivière's report, page 6).

which flows at Babylon, and which *Dioscorides* and *Serapion* declare is the best of all Bitumens. More discerning writers attribute igneous properties to it, and assert that it is formed mainly in sulphurous soils from the grease in earth and water, and which is raised by heat in igneous portions. Some persons believe it to be a variety of the white Balsam which *Pliny* in his Natural History says closely resembles Sulphur. In short, he adds, other persons have formed other opinions, and in my opinion they were not wrong in advancing the theory that Petroleum is the *aerial part of the true spirit of mineral Sulphur*, that it has more of *air* than of *fire*, although it does not entirely lose its igneous quality, etc.

Mathiolus (Comm. in Diosc.), Ruland and Ettmuller (Comm. in Lud. tit. 19) were less vague on this point than François Ariosto. They state that Petroleum is nothing more nor less than the Naphtha of the Ancients. Finally, M. Geoffroy (Mat. med. part. 1. sect. V, Cap. 1) of the Royal Academy of Sciences, Principal Doctor of the Faculty of Medicine in Paris, does not even question the fact, and regards the word Petroleum as synonymous with the word Naphtha. However, since there might still be doubts as to whether Naphtha and Petroleum are one and the same, it is perhaps useful to add to the proofs put forward by others the conclusion which can be drawn from the first of M. Marius' Remarks, quoted above. It is a fact that of all known substances, true Naphtha ignites most easily at a fair distance from the flame, and this was also the case with Petroleum; but M. Boerhaave (Elem. Chem. Tom. 3, page 191) adds that according to the Journal des Savants 1683, substances rubbed with Naphtha and plunged while burning into water, continue to burn while in the water. And, as has been seen, this is also the case with the Petroleum from Gabian, which was manufactured into a candle together with resin. We therefore believe we have good reasons for advancing the theory that the Oil from Gabian in no way differs from the Naphtha of Babylon, and that the two names *Naphtha* and *Petroleum* signify one and the same thing; for the Greeks called this mineral oil *Naphtha* because it ignites easily, and the Romans called it *Petroleum* because it comes out of crevices in a rock, carried along by water.

It may perhaps be said that it is more important to seek the medicinal qualities of Petroleum than to find out whether or not it is identical with Naphtha. We willingly agree with this; but it will also be admitted that anyone who is to be convinced of the resemblance and identical nature of these bituminous oils will find it less difficult to admit the characteristics of our Petroleum when he sees that they were atributed to Naphtha by Dioscorides and Pliny.

It will be said that knowing that Petroleum is identical with the Naphtha praised by Dioscorides and Pliny in their works does not add to our knowledge

of the properties of the former substance. But if on the one hand we examine the principles discovered by M. Rivière[a] in his chemical analysis, and on the other hand we consider what substances go into the making of *artificial* Soap, it will readily be understood that Petroleum is a natural *fossil* Soap, like the Balsams and Resins which flow from Trees and the Saps of Plants are natural *vegetable* Soaps. It would be useless to try to penetrate further into the nature of this Liquid; for it would seem that we shall never discover the intrinsic nature of natural Creation, and we shall have to content ourselves with comparing them with other parts of Creation whose composition we know. However, this knowledge, limited though it is, will enable us to explain the properties of Petroleum, since a knowledge of its properties would if necessary confirm your theories about its nature; and such harmony between the cause and its effects and the effects and their cause is practically all that can be desired in these matters.

It will be objected that M. Rivière obtained better results by comparing Petroleum with Oil of Amber; but since the intrinsic nature of this Oil is no more familiar to us than that of Petroleum, and since it is hardly possible to form ideas by making comparisons with some substance whose composition is unknown to us, we have not hesitated to differ on this point from the theory of this learned Chymist.

Moreover, even if today we did not know, or if we disregarded the fact, that in order to make a Soap all that is needed is an Oil and an alkaline Salt, a Remark made by the Academician of Montpellier in connection with the special features of the soil at Gabian would have led us to believe that Petroleum is a natural Soap. This Soil, he says, contains many bituminous concretions: the most remarkable are those which were found some years ago when excavating soil on a Mountain which is near this Village; it could, he adds, be called fossil or natural Soap, for the women of this region, so I am told, used it as Soap for doing their washing. These soapy concretions were examined in their mine, and it was observed that they gave off an odour similar to that of Petroleum: they were as hard as cakes of soap and shortly after being dug out and exposed to the air, they became as hard as old Plaster and some were a fiery red in colour and others the colour of mottled Soap. Might it not be presumed that this Soap was merely Petroleum which had come into contact with some calcareous soil, or some water similar to the limewater

[a] Apart from the properties which M. Rivière has found in Petroleum, and which we have mentioned above, it may be presumed that by applying the method of *M. Hales* a considerable quantity of air would be extracted; for this is found in abundance in all animal, vegetable, and mineral substances; and according to this Author, its role is important. But as far as we know it has not yet been possible to find out definitely what is the function of this air.

which is used in the manufacture of cakes of soap. Finally, another remark[a] by this Academician might help us to discover how Petroleum is formed, or at least serve as a basis for a hypothesis, but this would take us too far."

The theory that "mountain balsam" (unctuous petroleum such as that from Gabian), asphaltic bitumen and resin or amber were all connected is not new. It was already vaguely mentioned by Agricola in his De Ortu, but with particular dash and conviction by Andreas Libavius in his Singularium (Pars Prima: Liber de Ortu et Natura Succini diatribe (P. Kopff, Frankfurt, 1599).) Libavius states that all kinds of products such as mountain balsam and asphaltic bitumen originate in the resins of various trees and illustrates this by pointing to the similarity of their solubility and the sulphurous smell they all give off when burnt, and the nature of the residue when they are distilled[1].

The author of our pamphlet now demonstrates, on the basis of the supposed composition of petroleum, what maladies can be cured by it:

"Now, having regard to the saline and oily parts[b] of which Petroleum is made up, and assuming that it is a natural Soap, it will be seen that this Oil, as M. Rivière has said, is capable of attentuating, dissolving and melting the viscosity of lymph and the other humours, to reduce the acid acrimony of these and to restore their fluidity and movement: that it is suitable, when properly used and after employing the customary Remedies, for all maladies caused by cold or which are marked by a thickening of the lymph and the other humours, and an excessive weakening of the solid part."

The writer then sums up the medical properties of petroleum as found in Dioscorides and Pliny, and tells us that he read in Ariosto's book that a great many cures had been effected at Modena with petroleum, and reports some twenty of these in more detail. He quotes the opinions of various later medical writers, all of whom favour petroleum, and then comes to the specific properties of the oil from Gabian:

[a] There are, says M. Rivière, coal mines in this region and vitriol is also extracted; there are also those types of stone called *Belemnites* by Naturalists, which are extracted from a clayey soil. In Prussia much the same substances were found when on the orders of Frederick who was then on the throne, excavations in the ground were made in order to find veins of Amber; this caused M. Fried. Hoffmann (Obs. Phys. Chym. lib. 2, Cap. 23) to put forward his theory on the formation of this bitumen. Taken him as an example, we also could put forward theories about the formation of Petroleum; but we prefer to wait for further knowledge of the subject.

[1] R. J. Forbes, Das Bitumen in den fünfzehn Jahrhunderten vor Drake (300-1860). Bitumen, 1937, Nos. 1-6.

[b] Although we have not mentioned the aerial parts, we do not think that they have no function in Petroleum: it is even possible to obtain some idea of the manner in which they contribute to the effects of this fossil Soap by referring to what has been said elsewhere (Elem. de Med. Prat. Tom. 2, p. 9) about the way they act in Alicante Soap; but all this has not yet been developed enough to enable us to speak with assurance.

"M. Rivière says that Gabian Oil is useful in cases of Burns, Chilblains, Wounds, Colic, Worms in Infants and Post-Natal pains; and he adds a remark made by a Surgeon at Gabian that two or three iliac passions were cured in various persons by two doses of Petroleum of four ounces each. He also says, and experience has often confirmed this, and continues to do so every day, that Petroleum is very good for pricks in horses, which it cures thoroughly and in a very short time. Finally, he recounts the experience of a man whose thumb had been crushed by an extraordinarily large stone which had fallen on it, and was cured in the space of a week, without suppuration, solely by the application of this Oil.

M. Geoffroy (Mater. Med. part. 1 de fossil fech. V. C. 1. Edit. 1741) also greatly values Gabian Oil. He recommends it in cases of uterine suffocation, in the cessation of menstrua, and for the elimination of Worms in Children. He adds that it can successfully be rubbed on to paralysed limbs and nervous parts where there is a cold pain."

Now comes the actual kernel of his dissertation. The Oil of Modena is no longer what it was through all kinds of geological causes, but that of Gabian is however unchanged in its curative effect. He goes on:

"Such favourable testimonies leave no doubt that Petroleum has always been and still is an excellent Remedy; and our next remarks will show that Gabian Petroleum is preferable to that from Modena[a] and is nowadays the only one whose qualities can be relied upon.

Ramazzini (Epist. de ol. Mont. Zibin) admits that the Petroleum from Mount Gibbius in the Duchy of Modena no longer works the same marvels as it did in the time of Ariosto, and he rightly supposes that its properties must have declined. He even tries to find the reason for this change, and attributes it to great floods, earthquakes, subterranean winds, and to disturb-

[a] As far as is known, there is no other true Petroleum in Europe, apart from those of *Gabian* and *Modena*; and Naphtha is no longer brought from Babylon, nor from the East Indies, where it is so highly esteemed, for according to *Bontius* (Hist. nat. et médic. Indiae orient. lib. 2 cap. 1) the King of Achem forbids it to be taken away from the Island on pain of death. As regards the Naphtha distinguished by *Dioscorides* as black and white, and which according to *Strabo*, *Pliny* and *Plutarch* flows in the regions near Babylon, Susa, Arbela, and Ecbatana, M. Kämpfer (Amoenit. exotic. p. 274 et seq.) who travelled in Persia at the end of the last century, and stayed for some time at *Sjamachia* (Baku), the capital of Northern Media, states that there is no medicinal use of white Naphtha, which is only used for thinning Varnish. As regards black Naphtha, they use it in their lamps instead of oil. He even says that true Naphtha is not white; but that it is called white, to distinguish the kind which is purer, clearer and more liquid from the kind which is less pure, and is black, thick and opaque. He states finally that white Naphtha flows there in such small quantities, and that there is so little regard for it that this precious natural deposit is left alone, without guard and without walls, and that he himself would not have recognised the source which he visited if those who were with him had not pointed it out to him.

ances which have upset the bowels of the earth; just as in the human body there are maladies which upset or hinder the flow of the humours. For, he says, since thé mountains where the Petroleum flows have been subjected to much shaking owing to the frequent eruptions of the nearby volcanoes, it is not surprising that in the space of two centuries this oil should have lost a great deal of its effectiveness, and that nowadays it does not effect such astonishing cures as it did in the time of Ariosto.

Now, since none of the causes alleged by Ramazzini have affected the Petroleum at Gabian, for since 1608, when this precious Oil was discovered, nothing has occurred which might have an adverse effect on its efficacy; there are no great rivers in the neighbourhood, thus the low hills which surround the spot, and from which presumably it flows, are not subject to earthquakes; since there is no volcano there, we may safely say that this Oil has retained its first purity, and that it produces today the same effects as it did at first: in a word, that it has all the qualities attributed by writers to Petroleum in general. The only thing is that it is slightly less abundant; this should make it even more highly esteemed, and more eagerly sought after."

It is striking that he is so convinced of the merits of the Gabian oil that he only mentions the most important competitor, the St. Catherine oil of Monte Zibio, and does not even name the St. Quirinus oil of Tegernsee or one of the other central European petroleums, which were well known to the doctors of the time.

The writer now thinks that the time has come to give a more accurate description of the application of Gabian oil:

"It only remains for us to give more precise details about the cases when this oil is suitable for application, and to distinguish them from those when it might be useless or even dangerous, to note the method of use, and to mention the preparations and precautions required when using it.

Petroleum oil is taken internally or else applied externally; it is known by experience that it has penetrating, balsamic, aperient, diuretic, diaphoretic, vermifuge, emmenagogue, anti-spasmodic, anodyne, and anti-hysteric qualities, and that when applied in the form of a liniment, it is resolvent and very effective in the curing of contractured, weakened, stiffened or paralytic members."

He then deals with internal application for "Worms in Children", "Bilious Colics", "Iliac Passion" and "Hysterical vapours", and finally comes to external use:

"This Remedy taken internally can also be useful in cases of Dysentery, Quartan Ague, Flatulence caused by poor digestion, and as a preventive treatment against contagious diseases; but more information is still needed for more specific recommendations.

As regards the external use of this Remedy, it has already been seen that it is suitable for Burns and Wounds[a], for scrofulous Tumours, Chilblains, Itch, old rheumatic Pains, the Contracture of Members, Gout, Sciatica, Paralysis, Toothache, old Ulcers, and that it is a Specific for Pricks in Horses."

But this is by no means all, for our author believes that there are possibilities of other new applications, which should be carefully investigated:

"Finally, could we not supplement certain Mineral Waters, which, according to M. Malouin (Transactions of the Academy 1746, p. 115) derive their principal qualities from Petroleum and lose them in transit, by making artificial Water with this Oil? It is what one might expect from the sagacity of this skilful Chymist and learned Doctor.

This is not all. Petroleum can be used in many compounds. Ettmuller (Comm. in Schroder lib. 3 cap. 32) makes a liniment with it which he recommends after the usual remedies for the relaxation of tendons followed by numbness and incapability of movement. He makes it out of three drachmas of Petroleum, two drachmas of human fat and the same amount of goose grease, and prescribes that the part in question should be rubbed morning and night, subsequently applying Crollius' tryptic plaster or Diachylum cum Gummis.

It is also possible to add to Petroleum the marrow of Beef, and other oils, such as that of Amber, of Nutmeg, of wild Myrrh Oil, etc., for external applications. In brief, the more we consider the substances which make up this mineral Balsam, the more we find cases in which it may usefully be applied, and methods of combining it with other drugs whose presence may increase or modify its properties. We do not doubt, for example, that the Mercurial Unguent (Diss. sur la Rage by M. de Sauvages) would be more effective against the bite of a mad dog, if instead of quenching it with Turpentine oil, he had combined it with Gabian oil before mixing it with Lard. We even think that in the case of a slight wound caused by a mad dog, Gabian oil alone would be of great assistance in preventing hydrophobia, if after properly scarifying the bite and making the blood flow it was immediately rubbed with this Oil, and also the surrounding parts, and to continue to do so for some time. We also believe that if any Remedy can dissolve bilious concretions which sometimes form in the gall-bladder and which cause violent colic, cardialgia, vomiting etc., a judicious use of Petroleum, after taking the necessary

[a] For simple wounds, a bandage is soaked in hot Petroleum; the sore is bathed with the same oil, and this bandage is the only dressing, which is renewed, if necessary, every 24 hours, or else the sore is cleaned, and it is exposed to the smoke from several drops of petroleum scattered on hot coals, and then covered by a pledget soaked in petroleum. M. Rivière *Ibid.* Before applying the Petroleum, all the blood must have been extracted from the wound, and the edges should be brought together.

precautions, will effect this most rapidly. And if it is true, as M. de Réaumur asserts (Mém. de l'Acad. R. des Sciences. 1728, p. 311, E.f.) that the odour alone of Turpentine Oil kills the Moths which devour Woollen Cloths and Furs, it may be presumed that Gabian Oil would kill them more quickly.

In brief, we believe that in the case of the infectious sore throats which have been prevalent in Paris during the last few years, the fumes of Petroleum would have been as effective in drying out the Ulcers which remained after removal of the gangrened parts as was the smoke of white Amber, according to Severini, in the case of a similar malady which was prevalent in Naples at the beginning of the seventeenth century.

Then he hastily adds a last footnote:

"Unadulterated Petroleum Oil has not the fault of vegetable oils, as it does not go rancid; and provided that it is kept in a well-corked bottle, it can be transported into the most remote Countries, and be kept for as long as is desired, without any risk of its becoming tainted, or losing its efficacy."

This pamphlet, dated 17th February 1752, is not so important for its medical opinions, which we can no longer follow or share, but for two other reasons. In the first place it is a splendid example of the way in which judicious scientific propaganda was made for a local product which had to compete with other petroleums which had already been on the market for centuries. It cannot be denied that this document puts forward all the then known arguments for the medical use of petroleum in a dignified and responsible manner. In the second place, it is an interesting document which reveals to us the opinions of the eighteenth century with regard to the composition and origin of petroleum.

We cannot check whether this was successful, as our sources reveal practically nothing about Gabian Oil, although we have the impression that the yield of the seepage gradually declined. In 1807, Chaptal remarked that this "Font de l'Oli" and other bituminous outcrops in the Montpellier district presumably originated through the distillation at low temperature of underground sulphurous coal deposits, and wanted geologists to trace the route of the oil by means of this sulphur content from the coal deposits to its present reservoir.

Further examinations carried out on the site by M. Sabatier, of Pézenas, in 1840-1841 and those of an Englishman in 1865 have no results. Not until 1883-1886 were two bore-holes made in this area, reaching 410 metres, but both holes remained dry. Silence then reigned over Gabian until the Geology Section of the Petroleum Scientific Committee, set up by M. Pineau, decided at its meeting of 19th June 1923 to explore for oil at the foot of the Pyrenees. In August 1924 the first modern drilling was started, based on data obtained from a previous geological investigation and this was immediately successful.

CHAPTER TWO

EYRINIS D'EYRINIS AND THE BITUMEN INDUSTRY

Each period has its industrial pioneers, men who propagate new constructions and materials with the enthusiasm and fanatical energy so characteristic of the inventor. Eyrinis d'Eyrinis, the man who in the eighteenth century rediscovered bitumen and its properties as an engineering material, was a typical representative of this type of men. We know very little of his personal life. He claims to be a Greek by birth, a doctor of medicine and a teacher of Greek and other languages. From his publications we know that he must have been a good linguist, who certainly knew his French, Latin, Greek and Hebrew. About 1711 he seems to have lived at Bern teaching Greek and other languages in the service of the Bernese government. During that same year he visited Neufchatel and this visit was a turning point in his career.

The bituminous limestones of the Neufchatel region had not been unnoticed in earlier years. In a document of 1626 "hertzerde" (resinous earth) is mentioned amongst the mineral products of the region. In 1692 Amiest in his "Description de la principauté de Neufchatel et Valangin" mentions that "the manor of Travers has both coal and carbonaceous earth". When Eyrinis visited the region of Travers and the Areuze valley in 1711 on an official mission from the Bernese government, he met a German adventurer, named Jost, who, with some of his countrymen, had blasted some of the soft combustible rocks on the sides of the valley, and finding them worthless as a fuel, were trying in vain to find a use for them.

Eyrinis, who became interested in the subject, examined the rocky sides of the Areuze valley, finding that the same soft oil rocks protruded everywhere and discovered a particularly rich bed in the neighbourhood of Blois de Croix. A proper description of these strata was not given until the end of the century. [1] Eyrinis was less interested in the geological aspect of these bituminous limestone strata, he set to work and experimented. His first publication on the Val de Travers asphalt dates back to 1712, it was the first of a long row

[1] Frederic Osterwald, Description des montagnes et des vallées qui font partie de la principauté de Neufchatel et Valangin (Neufchâtel, 1776).

of pamphlets [1] in which our inventor proposed to put the bitumen to a series of medical uses as he was sure that it would cure rheumatism and other scourges of mankind, also claiming that it should be used as a base material for the perfume industry because of its "aromatic" nature and that it should be used in protecting farm buildings and storage bins as it was poisonous to field mice and insects.

Henri Fournel, who later worked at Val de Travers, when these mines were exploited by the Count de Sassenay, gives a long extract of the first pamphlet by Eyrinis, [2] which reads:

"The author, who, in the course of his long journeys has been able to perfect the knowledge he has acquired of all manner of minerals, and who has obtained from several ruling princes, notably H.M. the King of Prussia, permanent, far-reaching and most favourable rights to exploit the mines he has discovered in the realms of the said monarchs, having with God's blessing found in the principality of Neufchâtel a mountain which bears a true asphalt, to all intents and purposes as good as the asphalt of Babylon or that of the valley of Sydim, so well-known to the savants, and having already caused a considerable quantity thereof to be extracted, has deemed it purposeful to instruct the public thereanent by these few lines pending the publication of his work entitled: *Asphaltasphaliae, sive invertibilis bituminis veritas ac securitas.*

Since this asphalt consists of a thick, warm, mineral substance, stickier and more viscous than pitch, having few pores and of great solidity, as is indicated by its weight, it has such great resistance to air, cold and water that they are unable to penetrate it; it is therefore more suitable than any other material for joining together and tarring all manner of structures, for it preserves the wood from decay and protects it from worms and the ravages of time to such an extent that even if it be constantly exposed to water, air and frost and to all the onslaughts of the elements, instead of being damaged thereby it only becomes, as it were, the more incorruptible. It is therefore easy to conclude that this is a true natural cement, eminently suitable for

[1] Eyrinis, Eyrinis d', Dissertation sur l'asphalte ou ciment naturel découvert depuis quelques années au Val de Travers dans la comté de Neufchâtel, par le sieur E. d'Eyrinis, professeur grec et docteur en médicine, avec la manière de l'employer tant sur la pierre, que sur le bois, et les utilités de l'huile qu'on en tire. (Ph. N. Lotin, Paris, 1721, 12°, 50 pp.) — Eyrinis, Eyrinis d', Avis sur l'usage d'un asphalte ou ciment naturel trouvé par . . . le sieur E. d'E. (Paris, 12°, 60 pp.). — Eyrinis, Eyrinis d', Avis sur l'usage médicinal et les vertus de l'asphalte, de son huile et de l'huile de naphte, par le sieur E. d.E. (12°, 60 pp.). — Eyrinis, Eyrinis d', Descriptions des lois des mines en latin et en francais par M. E. d'E. (Besancon, 1721, 12°, 80 pp.). — Eyrinis, Eyrinis d', Réponse à un extrait du Journal des Savants, page 110 hebraique, grecque, latine et francaise. Asphaltasphalia prima, sive invertibilis bituminis vertas ac securitas cum allis asphaltasphaliis et Alysteria, ou Véritable Histoire de la Découverte de la Mine d'Asphalte. (Besancon, 12°, 88 pp.). — Eyrinis, Eyrinis d', Propriétés de l'asphalte ou ciment natural, de l'usage de son huile, ses vertus merveilleuses dans la médicine et l'agriculture, etc. par M. E. d'E., docteur et professeur grec (Neufchâtel, 1784, 8°, 48 pp.).

[2] Henri Fournel, Notice sur la Pierre Asphaltique du Val de Travers (avec une préface de M. le Comte de Sassenay) (Paris, Everat, Mai 1838).

joining timber, stone and divers other materials from which are built bridges, fountains, ships and all other structures which are exposed to water or damp.

The usefulness of this asphaltic cement has already been recognized in several places in Burgundy, Neufchâtel and Switzerland, and it has been used with great

DISSERTATION

SUR

L'ASPHALTE

OU

CIMENT NATUREL,

DECOUVERT DEPUIS QUELQUES années au Val Travers dans la Comté de Neufchatel par le ſieur EIRINI D'EYRINYS, Profeſſeur Grec, & Docteur en Medecine.

Avec la maniere de l'employer tant ſur la pierre que ſur le bois:

ET LES UTILITE'S DE L'HUILE QUE L'ON EN TIRE.

A PARIS,

Chez PHILIPPE-NICOLAS LOTTIN, ruë S. Jacque, proche S. Yves, à la Verité.

M. DCC. XXI.

Avec Privilege du Roy.

AVIS

SUR L'USAGE

D'un

ASPHALTE

Ou

CIMENT NATUREL

Trouvé par

le Sr. E. d'Eirinis

de Ruſſiene Doct. & Prof. Grec.

Geneſie Cap. VI. v. 14.

Bituminabis eam Bitumine
Et la calfatreras d'Asphalte.

Item Cap. XI. v. 3.

Et Asphaltus fuit eis vice cœmenti
Et l'Aspalt leur fut au lieu de Ciment.

S. 1332.

Fig. 2. The titlepages of two pamphlets by Eyrinis d'Eyrinis

advantage for cementing or tarring numerous wooden and stone structures which are exposed to water. The trials have always been very successful, and, if need be, the author can produce numerous witnesses to this fact.

There can be no doubt that when this substance is more widely known, it will be sought after by all builders, not only because of its good quality, in which respect

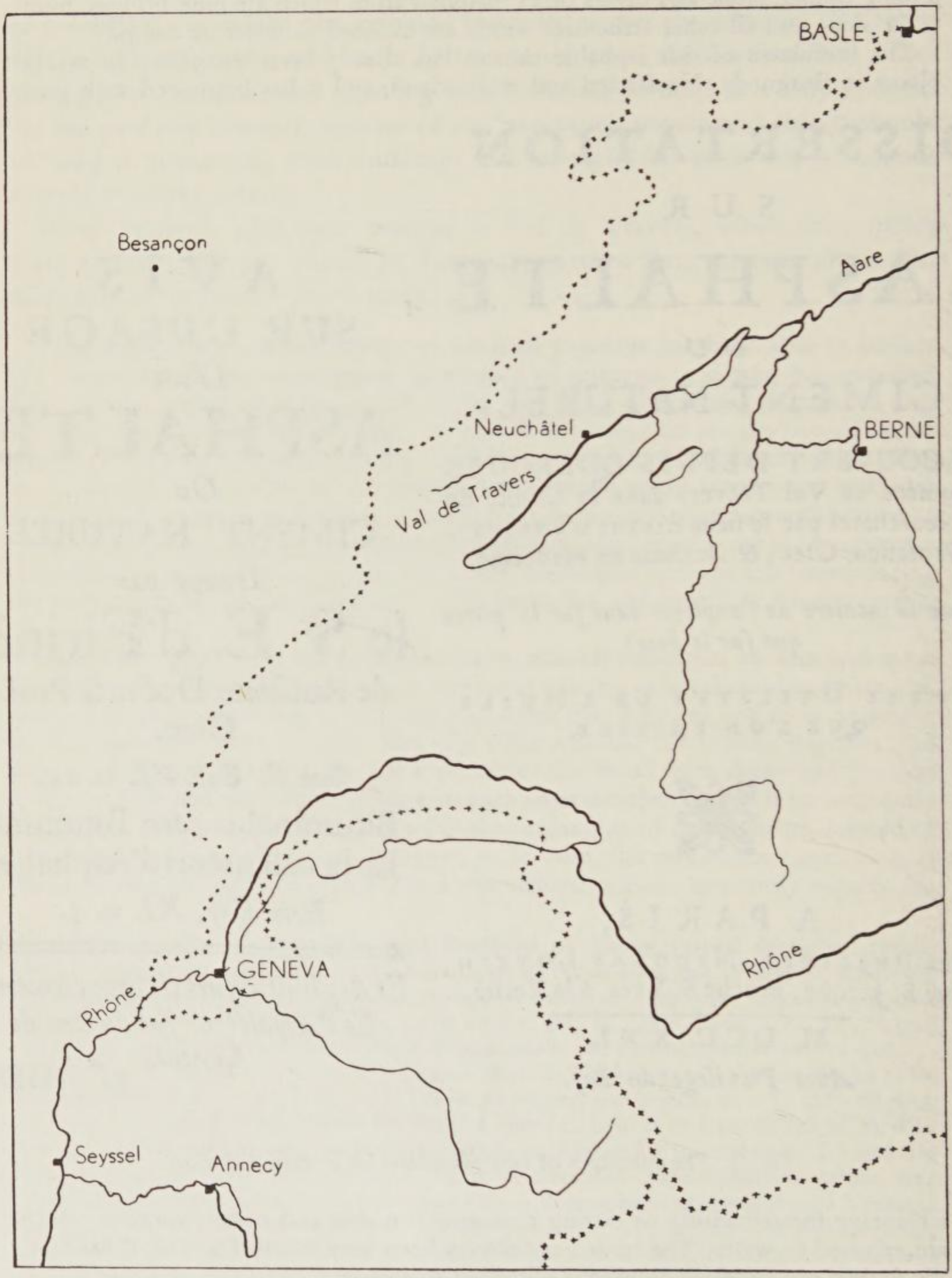


Fig. 3. Map of the Seyssel-Neufchatel region

it equals or surpasses other cements, but also on account of the ease with which it is prepared and the fact that it is cheaper than all the artificial cements now made.

The preparation of the cement is very simple: the material is taken just as it comes from the mine; it is warmed slightly to enable it to be coarsely pounded; a little pitch is added to make it melt more readily and render it more fluid; it is then melted gently over a coal fire. The wood or stone to which the cement is to be applied must be well dried and slightly warmed. At present one pound of pitch is used to ten pounds of asphalt to make a cement for stone. If a wood cement is desired, more pitch must be used. But as to this mixture, it is left to the artisans to find the proportions most suitable for their purposes; suffice it to add that the more the aforesaid asphalt is remelted, the more soft and pliable it becomes. However, a little pitch should be added whenever the asphalt is remelted, this being done in a copper pan, which should contain as much of the material as it may be necessary to apply.

Note: "First melt the pitch and add the asphalt little by little, whilst constantly stirring with a stick or spatula until the mixture is complete. Resin renders it harder and more resistant to the sun. Holland pitch, extracted from the roots of trees, causes it to become more adhesive. The quantity of pitch to be mixed with the asphalt is an eighth or ninth part of the former to one of the latter (that is to say common pitch to asphalt), according to whether greater or lesser fluidity is required; often it has been applied and before it has completely cooled, a hot iron (similar to those used by masons for their bastard cement) can be used to make it thoroughly smooth and even. Above all it is necessary that the workmen take great care to clean the stone or other materials properly before applying it, for if any defects be subsequently found, they will in no way be due to the said substance, but to the manner in which it was applied.

It should also be observed that asphalt in cement used in fountains, happening to be removed after many years, can be melted down again, and that it even becomes finer and stronger as a result of this remelting so that it can be used again for the same purpose, and that it preserves from all corruption the pitch that has been mixed with it. It will not be difficult to persuade the public of the truth of this if only it be considered that (as stated hereinbefore) the said asphalt serves to mummify and to preserve several other bodies which are infinitely more subject to decay than the pitch we have just spoken of.

If, when the basins of fountains are being cemented, any blisters or small bumps should perchance occur at the surface of the asphaltic cement, or any cavities underneath, which is noticeable at the spots where the said cement seethes or bubbles, all that is necessary in order to remedy this is first to rub these spots lightly with a small piece of cold tallow and then, while the said cement is still hot, to pass an iron bar over them two or three times (having presumably taken the precaution of placing the bar in the fire first); this will immediately remove all these inequalities and unite them in a surface as smooth as a looking glass."

In the days of Fournel the mastic was prepared by mixing the powdered rock asphalt with coal tar pitch instead of the wood tar pitch which Eyrinis had used. Eyrinis had applied to the King of Prussia (under whose protection Neufchatel was at that time) for a monopoly of all rock asphalt beds which

he might discover in the principality of Neufchatel and he had been granted this request after due and careful inquiry.

From the above extract it will be seen that Eyrinis had discovered the essentials of the preparation and application of bituminous mastic. He now set forth to demonstrate the importance of his inventions in the way of a modern company promoter. Apart from his books, which often have the character of a marketing pamphlet rather than that of a scientific essay, we also have official documents which he had drawn up after certain public demonstrations. The first relates to a series of experiments (1714-1716) for the coating and protecting of the timber and stonework of numerous cisterns and wells as well as platforms and a warehouse, which he paved to the satisfaction of the owners:

"Attestation given to Eyrinis by Paul Henry, Esq., surgeon of Cortaillod in the principality of Neufchâtel, Boudry, 17th August 1716.

Before me, notary, undersigned there appeared Paul Henry, Esq., surgeon of Cortaillod, who declared that on various occasions he had used cement made from the mineral asphalt of M. d'Eirinis de Russienne, doctor of medecine and teacher, of Greek nationality; the said M. Henry having cemented the basin of the fountain at Boudry, which is built of hard stone, he was paid for this work five batzen (fifteen French sous) for every pound of cement used. He then cemented the basin of the fountain at Arberg, for which he was paid six batzen (eighteen French sous) for each pound of cement, in addition to his food and his daily wage during the time he was working. Item: the fountains in the villages of Cernier and Motiers, which are also of stone; also the stone basin of the fountain of Counsellor Steiger at Berne, the wooden basin of Treasurer Thorman of Concize, and the platform and storehouse of M. Jeanneret, Lieutenant Bailiff of Grandson; on all of which basins and platforms he used only the cement prepared by the aforesaid M. d'Eirinis and applied in the years 1714, 1715 and 1716; no complaints have so far been heard, his work being extremely good according to attestations given by the parishes in which he was employed. The foregoing was affirmed by the said Paul Henry, Esq., touching the hand of the undersigned, notary, in the presence of the brothers Isaac and Pierre Amyet, honourable burgesses of Boudry.

Frédéric Grellet,
notary, town clerk and
lieutenant of the town of Boudry."

This document shows how close Eyrinis came to the main application to which his mastic would soon be put, asphalt pavements. His work was of excellent quality. Fournel mentions that in the house of a M. Coulin of Couvet (Val de Travers) he found "a flight of steps, dating from this period, in which all the upper steps, which are of stone, were worn into holes; while the lower steps, which had been, of course, most used, being coated with asphalt, were almost entirely unimpaired."

Eyrinis followed up this document with a series of practical tests, carried

at in the canton of Basle in 1719, showing the tenacity of bituminous bonds between two stones:

"Attestation by the authorities of the town of Delémont in the diocese of Basle, 15th January 1719.

Since attestation of the truth cannot and must not be refused to anyone, the undersigned Jean-Guillaume Hennet, Doctor of Laws and burgomaster of the town Delémont in the diocese of Basle, and Jacques Cuenin, counsellor and architect in the said town, attest by these presents and truthfully certify that they saw with their own eyes and recognized by the experiment carried out on the ninth of this month the good quality and strength of a natural asphalt which a certain M. E. d'Eirinis, a native of Russienne in Greece, a doctor and professor of medecine of great renown, brought to and made known in this town; this they are able to do having witnessed the joining together and uniting of two stones broken in two pieces, the first being of very hard rock which, having been cemented with the said asphalt and then chipped with the point of a hammer by a mason, was thrown to the pavement from a first-floor window, whereupon it remained intact; the second, which was a piece of a round column consisting of stone somewhat less hard than the first, a little more than four feet in height and about a foot in diameter, was likewise joined together and cemented a quarter of an hour after the application of the said asphalt, so that although the stone was still hot, two men were able to take it by the two ends and carry it out of the house in which it had been cemented, and afterwards, when it had cooled, it was thrown upon the pavement without suffering any break or damage; they are therefore able to certify that the said cement, made with the said natural asphalt is perfectly good when tested. In witness whereof they have signed these presents and affixed their ordinary seals."

Like so many inventors Eyrinis never reaped the fruits of his inventions, though he was in charge of the exploitation of the open-cut mine from 1712 to 1736. Probably he lacked the capital to exploit them and hence his efforts to interest various people into backing his ventures. Here he met his fate. M. de la Sablonière, Treasurer of the Swiss Confederation took interest in Eyrinis' rock asphalt and diligently throwing his influence in the scales set out to conquer the French market for Val de Travers rock asphalt. By court order of the 21st of February 1720 he was granted a ten-year monopoly of the application of the Val de Travers asphalt in France and exemption from duties and tolls. Gradually Eyrinis faded into the background, de la Sablonière allowed himself to be regarded as the inventor in France and reaped the profits. He set out a depot for the rock asphalt in Paris and executed several projects in the Park of Versailles, also managing to have the East-Indiamen "Le Mars" and "La Renommée" careened with Val de Travers mastic. This mastic was the "basis of the composition, with which were united the marble and bronze of a beautiful vase, which de la Sablonière had the honour to present to the king in 1740. With this cement they repaired the basins at Versailles, as well as the beautiful vase to be seen in the pleasure grounds, on which is, in bas-

relievo, the sacrifice of Iphigenia". In 1743 this mastic was used to coat the basin of the big fountain in the Jardin des Planets, which Buffon 36 years later still found to be water-tight. [1]

However, over-advertising and injudicious claims did their work. The Travers rock asphalt slowly fell into disuse. True, Eyrinis left the Val de Travers in 1735 and settled in Alsace, where, living in retirement, he drew de la Sablonière's attention to the natural asphalt of Lobsann, who managed to obtain the concession to exploit it, but no good came out of it. The quarries of the Val de Travers fell into private hands, who worked them more and more exclusively for the oil to be distilled from the asphalt and to be sold, as Eyrinis had advised, for their medicinal value. But by the beginning of the nineteenth century this Travers mastic and its inventor seem to be equally forgotten. The quarries on the left bank of the Areuze were exhausted by 1837. We have to wait until 1820 when three Swiss started to exploit a concession on the right bank of the Areuze which was finally acquired by de Sassenay. After the lapse of the concession in 1868 it was first leased to the Crédit Foncier and finally to the Neufchatel Bituminous Rock Company which was founded with English capital [2] on December 15, 1870.

After this set back the bitumen industry had to start afresh. This time the raw material was obtained from Seyssel (Dept. de l'Ain) [3] in the Rhône valley near Geneva. It seems that some bitumen had been obtained by boiling the bituminous limestone with water as early as 1790, but the realisation of its importance is due to M. Perrigny, a native of these parts, whose attention was drawn to some ancient remains of fortifications near Pyrimont, a few miles north of Seyssel. When these remains, said to be Roman, were demolished the stones were found to be cemented with bitumen and the walls could be pulled down only with the help of gunpowder. Perrigny immediately perceived that this bitumen must have hailed from the bituminous limestone in the park of Pyrimont. Preparing some mastic for his own use he managed to waterproof the floors on his house on the banks of the Rhône, which up to that day had been very damp.

In the same year 1797 one Secretan obtained a concession (9 Fructidor of the year V) and started to make mastic from the Seyssel limestone by powdering it and mixing it with "mountain tar", extracted from local bituminous sand-

[1] Buffon, G. L. L. de, Histoire naturelle (Paris, 1749-1804, art. Bitumen).

[2] Hessel and Kopp, Mémoire sur l'asphalte des mines de Val de Travers; Actes Soc. helv. des Sci. Nat. Neufchatel, 1855, p. 154. — L. Neuburger, Zur Geschichte des Schweizer Asphaltausbeutung im Traverstal (Teer und Bitumen 1931, p. 237). — Rub, Gaston, Les mines d'asphalte du Val-de-Travers (Collection Mon Vallon no. 3, 1937, Fleurier).

[3] Lartigues, Rapport sur les bitumes de Seyssel et de Gaugeac (Mém. Acad. Royale de Bordeaux 26 août 1819). — Anon, Notice des richesses minérales du Département de l'Ain, Mine d'Asphalte exploitée (Journal des Mines, An IV, 1796, no. xiii, 45-47).

stone with hot water, or with wood tar. The same mistakes made by de la Sablonière were repeated here. The discoverers of the Seyssel rock asphalt were led astray, by the adaptability of the asphalt, to promote its use for many purposes for which it was quite unfitted. Its earlier popularity which it first attained was succeeded by a reaction and the Seyssel asphalt was eventually spoken of with as much contempt as it had been received with enthusiasm.

The long series of failures ended with the complete ruin of the company. Finally in 1832 the Count de Sassenay purchased the quarries and works. He had rightly perceived that the cause of the failure was the application of the rock asphalt to constructions for which it was unsuited by unskilled workmen. He set himself to remedy this and established an "atelier" for the instruction of workmen in the best methods of working and applying the asphalt, and no government works were executed except under the direction of these trained and skilled workmen. He did away with the use of coal tar pitch and used solely bitumen produced from the local bituminous limestone to produce his standard mastic, which consisted of 97% of rock asphalt and 7% of bitumen mixed with 30% of sand and sold in blocks of 25 kilogrammes at 30/— per 100 kilogrammes, later in casks.

By 1840 20 workmen produced some 200 tons of mastic per month at Seyssel. The production rose from 200 tons in 1820 to 1000 tons in 1835. When the concession was renewed on July 19, 1843 shafts and galleries were built to exploit deeper strata. Of course de Sassenay could no longer handle these affairs personally, he transferred his rights to a private company at Paris for the sum of £ 30,000. At the head of its executive department stood M. Equem, who in the twenties had persevered against all opposition in calling the attention of the French engineers and architects to the mastic of Seyssel and who had executed a variety of works with unvaried success. With men like de Sassenay and Equem this company flourished and its shares boomed, for the merits of bituminous mastic were now recognised, as is evident from a pamphlet on Seyssel asphalt [1] which Simms wrote in 1838 and from a paper by a geologist M. Rozet [2] written in 1836.

[1] Simms, F. W., Practical observations on the asphaltic cement or mastic of Seyssel, now extensively employed on the continent for pavements, roofing and flooring of hydraulic works, etc. (London, 1837).

[2] Rozet, Asphaltic Mine of Pyrimont (Bull. Soc. Géol. de France vol. VIII, 1836, p. 138). — Saussure, Theo. de, Procédé pour dépouiller le pétrole de Travers et quelques autres huiles minérales de leur mauvais odeur (Ann. Chim. et Phys. (2) 1817, vol. VI, p. 308). — Henry Jr., M., Comparative analysis of the elastic bitumen of England and France (Amer. J. of Science (1), vol. XIV, 1828, p. 371). — Laurent, Auguste, Sur les schistes bitumineux et sur la paraffine (Ann. Chim. et Phys. (2), vol. LIV, 1833, p. 392). — Rozet, M., Sur l'asphalte de Pyrimont (Bull. Soc. Géol. de France (1), vol. VII, 1835, p. 138). — Anon, Asphaltic mine at Pyrimont (Seyssel) (J. Franklin Instit. vol. XXVI, 1838, p. 276). —

At Travers new richer strata (with 11-12% bitumen) were discovered on the right bank of the Areuze. The original concession of this "Mine de la Presta" was renewed and granted to one of de Sassenay's friends, M. Brémond de Saint Paul on November 11th, 1837, for a period of 30 years, to be extended in 1838. In 1838 de Sassenay visited the Val de Travers mines together with Henri Fournel and satisfied himself "that it contained a very rich bed of asphalt stone similar to that of Seyssel (6-8% bitumen), only of a finer texture, and containing 2 per cent. more bitumen (ca. 10%), which is a valuable quality as it saves the necessity of adding that amount of tar". He succeeded in purchasing the monopoly and established a company for the sale of Travers asphalt at Paris. Between 1840 and 1850 the Presta mines produced some 3500 tons of mastic per year. In the same year (1838) a third company for the sale of Lobsann asphalt was established at that town by the brothers Dournay of Pechelbronn (Alsace). Shares of asphalt companies rose from 500 frs. to 12,000 and more, but soon fell to 50 francs, because too few experts like those from Seyssel were available. The final solution was the amalgamation of the three companies in the Compagnie Générale des Asphaltes de France (1856).

De Sassenay ranks with Eyrinis as a pioneer of the bitumen industry, because of his insistence on intelligent application by skilled men, for before the thirties too many failures had descredited bitumen. There were of course many successes to be recorded from the early decades of the nineteenth century. Mastic pavements on sidewalks and bridges were already numerous. In 1810 the Pont Morand at Lyons was paved with Seyssel mastic and also a bridge at Geneva, which was covered with $\frac{1}{2}''$ of mastic. Then followed a bridge in the fortress of Strassburg (1822) and the Pont de l'Arsenal of Lyons (1823). The floors of public slaughter-houses and horse-stables were successfully covered with mastic. It was used as a foundation of mosaic floor and for tiles. Mastic was used to paint and protect woodwork (for instance in the mine-shafts of Valenciennes) and to cover roofs. Mixed with tar, linseed oil or turpentine it was used as a glue for parquet floors and to "asphaltize" cables and heavy ropes. [1]

In his report on Seyssel mastic Simms mentions that by 1820 some 500 Paris roofs and at least as many at Bordeaux had been protected with mastic at 7/6 per sq.m. It had been a success in the abattoir of Montmartre and a certain Captain Gréban of the Engineers, who seems to have been in charge

Berthier, P., Analyse du calcaire bitumineux du Val de Travers (Neuchâtel) (Ann. des Mines vol. XV, 1839, p. 564). — Ure, Andrew, Report on the asphaltic rocks of Val de Travers, etc. (J. Franklin Instit. vol. XXVIII, 1840, p. 409).

[1] Payen, M., Mémoire sur les bitumes, leur exploitation et leurs emplois utiles (Huzard, Paris, 1824).

of new storehouses for the army, gave Simms an enthusiastic testimonial:

"It is but a few years since the attention of builders has been directed to the employment of the asphalte, and already the military engineers have extensively applied it in the fortifications at Lyons, Lisle, Belfond, Vincennes, etc. The artillery have covered the roofs of warehouses constructed several years since in the arsenal at Douai, which covering has perfectly withstood all the inclemencies of the weather. The naval department has also made numerous trials of it in their various buildings at the Port of Toulon: these trials have succeeded perfectly. The pavement there constructed of asphalte more effectually resists the continual friction of the chains and bullets, which the convicts are there destined to drag about, than the stone formerly used, and it does not admit of the prisoners secreting beneath its surface files and other means of escape as the pavement did. The daily ablutions are also performed more easily and the salubrity of the appartments gains much by it. These advantages have been so fully appreciated by the engineering officers of the navy at Toulon, that the government, it is said, intends to adopt the asphalte in the other ports of France.

The engineers of bridges and causeways, the architects of the government, those of the civil list and of the city of Paris, have long been well aware of the important services which the use of the asphalte could render them, so they have endeavoured to extend its applications. Among the principal works in Paris where it has been applied, I will mention the mosaic pavement of the Place de la Concorde, the water channels of the Boulevards, the school of liberal arts, the wine magazine, the abatoirs or slaughter-houses, the Pont Royal and Pont du Carroussel, the areas around several public fountains, etc. Many other important applications of the asphalte are also in contemplation. In the new church of St. Vincent de Paul now building, the flooring will be constructed with that material, instead of the free-stone used in other churches, and which is cold and damp in winter. Several colleges and houses of education are having their groundfloors and court-yards paved with asphalte. And lastly, in consequence of the enormous expense incurred by the cleansing of the numerous common sewers of the city of Paris, from their present roughness preventing the free running of the water, it has been suggested to have them lined with asphalte; experiments have accordingly been tried, and have proved that, with the greatest ease and comparatively but little expense, the filth could no longer stagnate therein as at present, and the noxious effluviae which consequently escape at the mouths of these common sewers would no longer infect the salubrity of the air."

Equem together with the captains Gréban and Coignet conducted experiments in which an arch was constructed from cylindrical pots cemented with

Seyssel mastic and also of lengths of thirty bricks cemented with mastic which proved very strong when exposed to heavy loads and bending tests. The experiences with the mastic pavement of the Pont Royal, over which 30,000 people were then passing daily, were very satisfactory. In 1835 the Place de la Concorde (about 24,000 square yards) was paved with mastic "laid down in elegant mosaic work, with the asphalt of Seyssel. The ease, rapidity and simplicity with which this is formed, calls forth the admiration of all passers-by. The fluid mastic is spread to fill a mould, formed of bar-iron of the pattern desired (here the design consists of large squares alternately black and white, each square having a circular disk in its centre of the contrary colour to itself), while the mastic is still fluid, a fine gravel is sifted over it, either white or black gravel according to the colour required, and then as the mastic sets the whole is beaten flat with wooden stampers of about fifteen inches long and nine broad; the pavement so done, and after a little wear, can scarcely be distinguished from granite."

Simms claims that mastic pavement cost about 5/10 per square metre (1.196 square yards) and he states that many "synthetic" mastics marketed by competitors were spoiling the market as their products were quite unsuitable. His pamphlet was, however, written in order to inform the English engineers of the characteristics and uses of the Seyssel mastic. It had been agreed that Seyssel mastic should now be marketed in England, even though the mastic pavement in Vauxhall, made by a competitor, had not been a success. R. T. Claridge was to handle de Sassenay's affairs in England. He obtained an English patent (No. 7489 of November 25, 1837) and his Patent Asphalte Company had its office at Stangate near Westminster Bridge. The pamphlet written by Simms summarised the French experience and suggested the possibilities of Seyssel asphalt in England. It had to compete with wood-block pavement, which was then held to be cheaper and healthier and rock asphalt only slowly won way. Though used on many footwalks, mastic pavement became popular only after its successful application to a part of Threadneedle Street in 1869, after which success Cheapside, Old Bond Street, Cornhill, Mansion House Street, Aldgate and Fenchurch Street followed rapidly. Mastic pavements were now also established in England.

Meanwhile new types of bituminous pavements had been invented. Macadam roads had been laid all over Europe during the first part of the nineteenth century, but not all of them were satisfactory. Many were dusty in hot weather and muddy in wet. Now on the roads and paths in the quarries of the Val de Travers the small pieces falling down from the carts were constantly pressed down and flattened by the cart-wheels passing and re-passing, till they at last formed a firm, solid, elastic surface on which the horses could

drag their loads with great ease, and which did not seem to be worn out by the traffic.

Henri de Coulaine was the first to put this idea into practice on the roads of the department of the Maine et Loire. The earliest experimental road (1837) was a stretch of the highway between Bordeaux and Rouen near the town of Saumur. Here a layer of broken stones, such as those for a macadam road, was laid down and over that asphalt broken up small, to a depth of $1\frac{1}{2}$ inch, and rolled. At first the new streets seemed a complete success. The asphalt soon became firm and solid; the stones were crushed down and the malleable asphalt filled the interstices. The impression made by each horse or carriage was effaced by the succeeding one and it did not appear to be affected by summer or winter. On the strength of this favourable experience many roads and bridges were paved in the same manner near Saumur, Angers, Tours and Briare.

In time, however, the drawbacks of this system became apparent. The crushed stone of the macadam layer mixed with the asphalt and destroyed its impermeability to dust and water. However A. Merian, a Basle engineer working along the lines of Coulaine independently, conceived a better solution of the problem. He laid down hot powdered Travers asphalt and rolled it with heavy rollers into an impermeable elastic surface. His experiment on a part of the high road between Serrières and Travers in 1849 was so successful that in spite of its insufficient foundation, this road remained unimpaired for the next twenty-five years. The French engineers were quick to take up this idea.

In the same year 1849 M. Darcey, Inspector-General of the Ponts-et-Chaussées, published a treatise describing the pavements of London and Paris and advocating the improvement of macadam surfaces with "cold asphalt" surfaces of the type Coulaine had propagated. Under his direction several of the Paris boulevards were thus paved, but he was soon convinced of the drawbacks of this system and recognised the superiority of the "compressed hot asphalt powder system" invented by Mérian, as this would yield a perfect amalgamation of the particles of asphalt.

The man who was to make this compressed asphalt a success was Léon Malo, who had worked at Seyssel since 1838 and who together with Vaudrey experimented on the laying of compressed asphalt surfaces between the years 1851 and 1854. They finally worked out a perfect system which allowed Vaudrey to complete a stretch of 700-800 m^2 of compressed asphalt in the Rue Bergère near the Conservatoire de Musique in 1854. Gillmore [1] reports that only $\frac{1}{4}$ in.

[1] Gillmore, Q. A., Roads, streets and pavements (New York and London, 1876). — De Coulaine, On the asphaltic macadamized roads lately laid down in Paris (Ann. Ponts et Chaussées 1850) (J. Franklin Instit. vol. LII, 1851, p. 216).

of this surface had been worn off in 15 years time and the surface lasted for over 60 years. Its success decided the authorities to pave the Place du Palais Royal in the same way (8,000 m²) and the Rue Faubourg St. Honoré followed. The Paris quarter between the boulevards and the Seine had some 800 m² of asphalt roads and sidewalks in 1852, in 1856 this had grown to 8,000, in 1866 to over 100,000 and by 1869 to no less than 280,000. The asphalt road had come to stay.

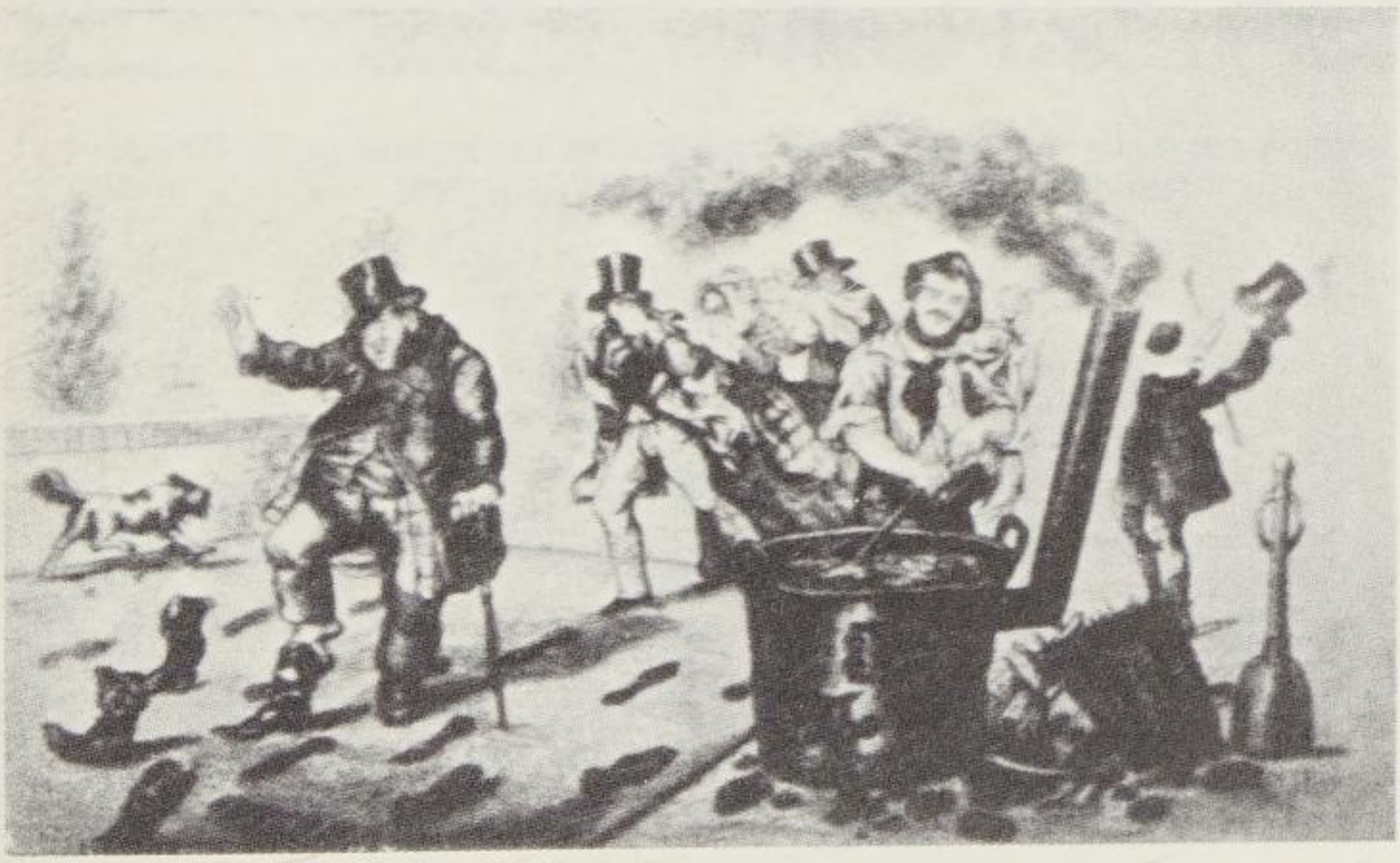
Malo describes his method in the following words: "The (Seyssel) asphalt stone is brought direct from the quarries and broken up into small pieces about the size of those used for macadamized roads; it is then heated over a stove, in a drum-shaped iron vessel with feet, till it crumbles into powder; and in order that the powder may not lose its heat, the whole apparatus is conveyed on to the street where it is to be applied. Then a foundation of "béton" is laid, about 4 in. deep, which may, however, be thicker or thinner, according to the nature of the soil. On a macadamized road the substratum of concrete may even be dispensed with entirely, whilst on a loose soil it may be made as thick as 6 in.

When the concrete has hardened, and been cleaned, it should be smoothed to the proper curve. The arch of the roadway ought not to be greater than is absolutely necessary to drain off the rainwater, in order that the horses may not slip on the incline at the side. The powdered asphalt is then spread over the surface, to a depth of 1.6 to 2.0 in. (according to the amount of traffic it is to bear), and stamped down; a roller of 2,500 to 3,000 kilogrammes is then drawn over it, to make the pressure perfectly even. Two hours later the road is ready, and may be opened to carts and carriages."

Further details on the development of mastic asphalt and compressed asphalt roads can easily be found in the many handbooks of the period. [1] Both the

[1] Baddely, The new pavement of London (Mechanic's Magazine 1831). — Baker, I. Osborn, A treatise on roads and pavements (London, 1903). — Beckwith, Arthur, Report on Asphalt and Bitumen (In Reports of the U.S. comms. to the Paris Exposition) (U.S. Govt. Print. Office, Washington, 1868). — Chabrier, E., The Applications of Asphalt (London, 1878, Proc. Inst. Civ. Eng. XLIII, 1876, p. 276). — Clark, E., Asphalt and its application to street paving (London, 1879). — Delano, W. H., On the use of Asphalt and Mineral Bitumen in Engineering (Proc. Inst. Civ. Eng. 1879/80, Part II). — Delano, W. H., Twenty Years Practical Experiences of Natural Asphalt and Mineral Bitumen (New York, 1883). — Dieterich, E., Die Baumaterialien der Asphaltstrassen (Berlin, 1881). — Edwards, P. J., History of London street improvements 1855-1897 (London, 1898). — Forbes, R. J., Das Bitumen in den fünfzehn Jahrhunderten vor Drake, 300-1860 (Bitumen, 1937, nos. 1-6). — Halleck, H. W., Bitumen, its varieties, properties and uses (U.S. Army Corps of Engineers, Papers on Practical Engineering) (P. Force, Washington, D.C., 1841). — Jeep, W., Der Asphalt und seine Anwendung in der Technik (1e edit. Voigt Verlag, Weimar, 1867) (2e edit. bew. E. Nöthling, Voigt Verlag, Leipzig, 1899). — Kayser, R., Untersuchungen über natürliche Asphalte (Nürnberg, 1879). — Malo, L., Note sur l'as-

French cartoon on the dusty macadam roads of 1840.



French cartoon on the application of Seyssel-mastic (1846).

The burning gas-wells of Baku in the "ager ardens" according to E. Kämpfer (Amoenitates exoticae, Lemgö, 1712, pag. 268).

Belgian engineer E. J. de Smedt and Clifford Richardson were instrumental in introducing a new type of asphalt road, sand sheet and asphaltic concrete, consisting of hot pre-mixed asphaltic bitumen with graded stones, sand and filler, to be spread and rolled into shape on a prepared foundation. Therefore by 1880 all the modern forms of asphalt roads had been invented and the bitumen industry firmly established on a scale beyond the imagination of even Eyrinis, the prophet.

phalte, son origine, sa préparation, ses applications, suivie de divers documents sur la matière (Baudry, Paris, 1863, 2. edit. 1888). — Meyn, Der Asphalt und seine Bedeutung für den Strassenbau grosser Städte (Halle, 1872). — Payen, M., Mémoires sur les bitumes, leur exploitation et leurs emplois utiles (Paris, 1824). — Peckham, S. F., Asphalt Paving (Report of the Commissioners of the City of New York, 1904). — Woas, F., Der Asphalt, seine Geschichte, Gewinnung und Verwendung (Berlin, 1880). — Zetter, J. T., Der Asphalt und seine Verwendung in der Bautechnik (Orell-Füssli, Zürich, 1880).

CHAPTER THREE

EARLY SPECULATIONS ON THE NATURE AND ORIGIN OF PETROLEUM

Though petroleum and some of its derivatives were known in the Middle Ages mankind did not speculate on its nature and origin. We find but vague statements on the "watery and fiery" nature of bitumens. Such statements were repeated many centuries after more specific and realistic theories had been propounded. Thus Blount's Glossary defines bitumen as "a kind of clay or slime, naturally clammy, growing in certain countries of Asia" as late as 1656!

Georgius Agricola (Georg Bauer) (1494-1555), the author of the first detailed handbook on mining and metallurgy, is one of the first to give a more reasonable view on such problems. He deals with the production and refining of crude oil and bitumen in the Twelfth Book of his De Re Metallica, [1] which discusses the "solidified juices". He deals with their nature more in detail in his De Natura Fossilium [2] where he classifies petroleum, coal, jet and obsidian, camphor and amber as varieties of bitumen, and devotes much space to the refutation of the claims that the last two are of vegetable origin. According to him "the cold of the seawater consolidates the liquid mountain-wax from under-water springs to amber and bitumen as I proved in my book De Ortu." [3]

These ideas were destined to affect general opinion for a very long time as Agricola remained the most important author on mining and metallurgy for nearly two centuries and was widely read. However, Andreas Libavius (Andrew of Libau, 1550-1616), the next most important author on minerals and their composition had more lucid views and details on this subject. [4] He studied the analogies between bitumen and amber which Agricola and Aurifaber had

[1] Georgius Agricola, De Re Metallica (transl. H. C. Hoover and L. H. Hoover; Dover publications, New York, 1950).

[2] Georgius Agricola, De Natura Fossilium (Basel, 1546, Book IV).

[3] Georgius Agricola, De Ortu et causis subterranorium (Basel, 1546, Books I and II).

[4] (Andreas Libavius) D. O. M. A., Singularium Andreae Libavii, cont. VIII libros bituminum et affinum historice, physice, chimice; de Petroleis, Ambra, Halosantho, Succino, Gagate, Asphalto, Pissasphalto, Mumia, Lithantrace (P. Kopff, Francfort, 1601).

stressed. These two authors had pointed out that both substances smelt alike, gave off the same sulphurous fumes when calcinated, were dissolved by the same solvents which would not dissolve ordinary resins and both yielded a yellowish oil when submitted to dry distillation together with a black pitch which proved to contain salt on further calcination. Libavius, however, points out that amber always contains fossils, but bitumen not. Also bitumen, like gagates (jet) and pissasphaltos (asphaltite) is often found to contain no salt at all. He therefore holds amber to be a fossil resin, but could not prove this as in his days the existence of pine trees on the Baltic coast in prehistoric days was still unknown. Experiments show him that "lithantrace" is just fossil coal, "pissasphaltos" a hard fossil bitumen, etc. According to him, though amber and bitumen are closely related products, the various types of coal and bitumens are more closely related. He devoted part of his efforts to the disentangling of the very crude etymology of this class of products and tried to define them more closely.

Though his books were less widely read than those of Agricola, his influence can be traced in the later writings of Boccone, [1] who a century later, claims that there are only differences in consistency between the different crude oils oozing from the seepages all over Europe and the harder bitumens and asphaltites found all over the world. He also believes amber to be a form of "hardened bitumen", though he cannot prove this exactly. For, says he, amber is found in Prussia between seepages of crude "petroleum" near Königsberg and Pilar. But this amber often contains minerals and other inclusions which have nothing to do with the resin of pine trees but which are related to strata of sulphurous and bituminous compounds. He quotes Walter Charleton, who had discussed the "Barbados pitch" in his Onomasticon Zoicon, and John Wigandt to prove that amber is but a form of bitumen. Naphta or rock oil differ only from amber in its consistency. The light and fine parts have evaporated leaving a thick, dense and hard mass which like amber attracts small pieces of paper or straw when rubbed and which boiled with nitric acid hardens and becomes a brittle substance. Both amber and bitumen have been distilled by natural forces such as volcanic action and inspissated in cavities in mineral bodies.

He points out that petroleum was found in several seepages in Sicily some of which stopped flowing after the earthquake of 1693, many of which seepages are found close by amber. A well in Prussia yielded inflammable gases and petroleum when deepened, which substances must have been formed from the bitumen below. Many other deposits of bitumen such as the "pitch of

[1] P. S. Boccone, Museo de Fisica (Venezia, 1679, pp. 35-37).

Castro" found at a distance of 60 miles from Rome, the natural asphalt of Sacca (Sicily) and other sites must have been formed by volcanic action from materials containing the "principle of combustibility" (terra pinguis) and the "principle of sulphur" (liquid sulphur). Hence the oils distilled "per descensum" from such bitumens or petroleum and from resin (the "oil called carabé") or from juniper berries ("Olio di ginepro") show very similar medicinal and other properties because they contain the same principles. The petroleum of Modena and Parma was formed by the same subterraneous fermentations stimulated by volcanic action, and like some of the natural bitumens oozes forth especially in spring or autumn. The fermentation seems to take place particularly in winter, but in some regions in spring.

The knowledge displayed by Agricola and Libavius differs but little from that of the famous pharmacist and spiče-dealer Pierre Pomet in his handbook of 1694.[1] Without analytical methods progress was hardly feasible. Pomet devotes an entire section of his handbook to the discussion of the "bituminous substances" which he defines thus:

"The word bitumen, properly speaking, means an inflammable, fatty, oily substance of various colours and consistencies, both underneath and on the surface of the earth, or floating on water, and that is why there are several kinds of bitumen, some hard, others soft, and yet others liquid like oil. The hard bitumens which we sell are yellow amber, gest, Judaean bitumen, Pisasphaltum, mineral coal, cannel coal and sulphurs. The soft varieties are Maltha, bitumen of Colao and Sirnam, and copal bitumen. The liquid varieties are Italian Naphtha and Petroleum, all of which are described below."

He then discusses "amber" (which includes all fossil resins, and which he also calls "succin" or "karabé") and its dry-distillation products, "gest or jayet" (which includes such widely different substances as jet and different types of asphaltites, formerly called "gagates" and which he holds to be the original matrix from which petroleum was formed), "live sulphur" (the native sulphur of Sicily) and even Indian ink. His descriptions of "Judaean bitumen" (natural asphalt), "ampelitis" (asphaltites) and "slimy bitumen" or "maltha" (thick crude oil) are worth reproducing:

"Cap. IV *Judaean Bitumen*

Judaean bitumen or Asphaltum is a bitumen found floating on the surface of the lake which now covers the former cities of Sodom and Gomorrha, the name asphalt originating from the name Asphaltic Lake, which means Lake of Confidence. This is indeed the case, for whatever is thrown into it floats on the surface. It is also known as the Dead Sea, since no fish or other creature can live in it, because it is extremely salt, bitter and evil-smelling, but on the other hand large quantities of this bitumen

[1] Pierre Pomet, Histoire générale des drogues (Loyson et Pillon, Paris, 1694 Pars III, Lib. iii).

are found there, floating like fat, and the inhabitants of the place, who are Arabs, derive great benefit from it, as they use it to caulk their boats, in the same way as the Northerners and ourselves use pitch. It is remarkable that when this lake has a fair amount of bitumen on it, there is such an evil smell that the inhabitants are forced to collect the bitumen and place it on the shore; the smell is so strong that any

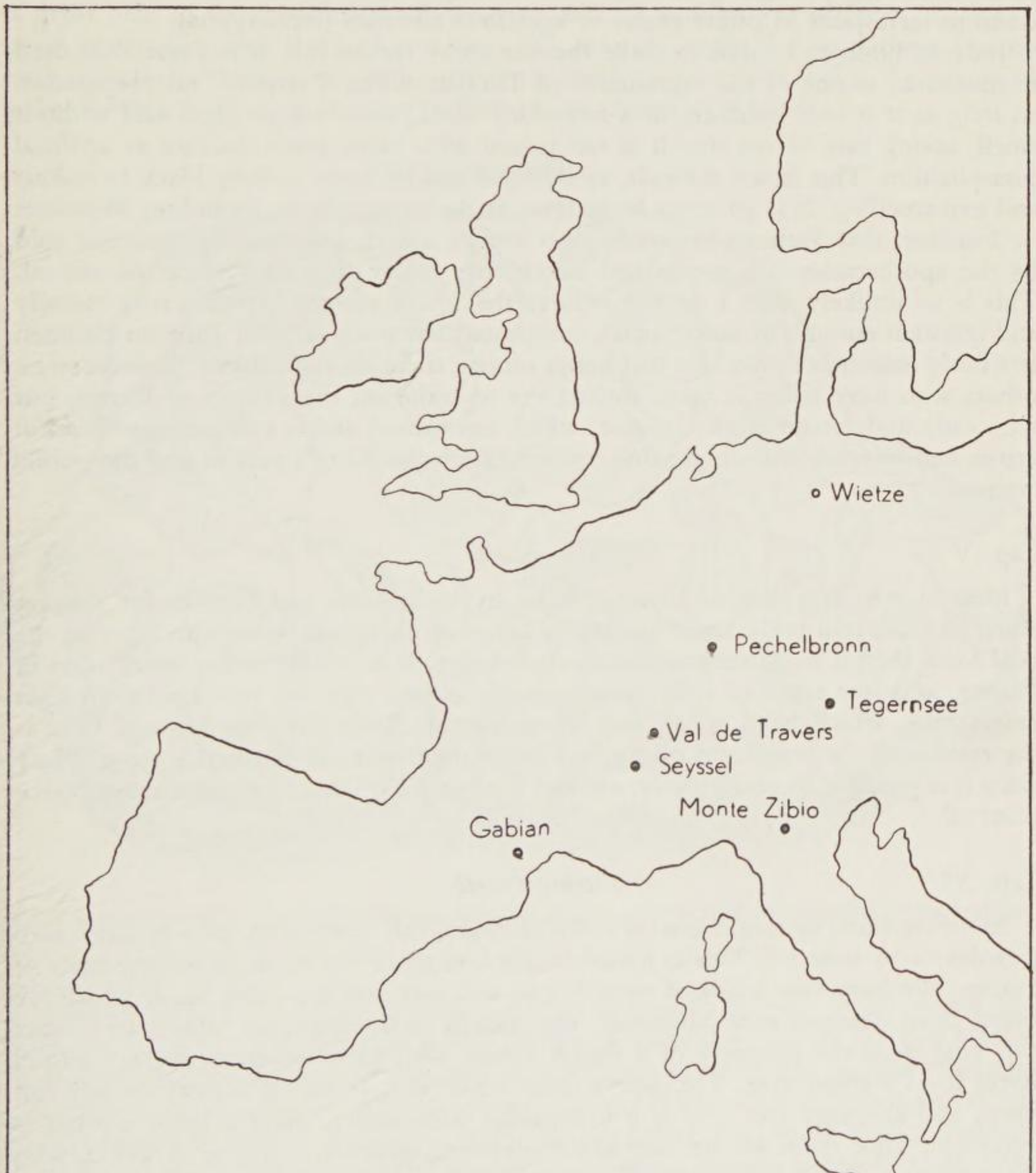


Fig. 4.

bird passing overhead falls dead into the lake, and that is why the inhabitants of this area do not live long.

Judaean bitumen, or asphalt, is so like our fine Stockholm pitch that if it were not for the smell and the fact that Judaean bitumen is harder, no one could tell the difference, and it was this similarity which caused the Prophet Esdras to call it pitch, in the following passage: gens mala memorare quid fecerim, Sodomae et Gomorae, quorum terra jacet in piceis glebis et agerribus cinerum (Apocrypha).

Judaean bitumen is used to make the fine shiny Indian ink. It is sometimes used in medicine, as one of the ingredients of Theriac, when it requires no preparation so long as it is true bitumen, of a fine shiny black, with a high gloss and without smell, taking care to see that it is not mixed with black pitch, known as artificial pisasphaltum. This is not difficult, as this artificial bitumen is dirty black in colour and evil-smelling. It is an error to believe, as do some writers, including Monsieur de Furtière, that Judaean bitumen is no longer found, and that the bitumen sold by the apothecaries is a compound which they make of pitch and petroleum oil. This is so unlikely, that I do not believe that there are any Apothecaries rascally and ignorant enough to make such a compound when we sell real Judaean bitumen at a fairly reasonable price. He had better remain silent on the subject ,likewise some others who have taken it upon themselves to write on the subject of Drugs, but who only understand High German, which has caused and is still causing dreadful errors and misunderstandings; this concerns both the King's person and the public interest.

Cap. V *Mineral coal*

Mineral coal is a sort of bitumen used by locksmiths and farriers for heating iron; English coal is the most esteemed, although there are some who say that the coal from the pit in Auvergne is scarcely inferior. It is a commodity much used in France, and our trade in it is very large. It is said that the best kind is the least sulphurous, which heats better and burns longer. Some say that Mineral Coal is the residue of the petroleum oil formed in the depths of the earth; this seems likely since it is possible to extract from mineral coal an oil which closely resembles petroleum oil.

Cap. VI *Ampelite earth*

Ampelite earth or cannel coal is a dry bitumen, full of sulphur, easy to crush into powder or to scale off. This is found in the bowels of the earth in several parts of France. We have two kinds of cannel coal, one soft and the other hard, which we bring from Alençon near Mayenne. The mouth of the pit from which we extract this coal is on the property of a Parish Priest, who gains seven or eight hundred livres from it every year. The quarry from which it is extracted is forty or fifty feet deep, and although this coal is a low-priced commodity, quite a large amount is extracted, since there are scarcely any tradesmen, either in stone or in wood, who do not use it. For this purpose, it must have been freshly extracted from the mine, since when it is old, it turns into powder and becomes saltpetre. It must be light, not too soft and not too hard, and properly dry. Some people call this substance terre-à-vigne (vine-earth), since it wards off and kills the worms which infest vines, and *pharmacitis*, because it is medicinal.

Cap. XV *Slimy bitumen*

Naphtha or clay bitumen is a bitumen or clay which is found in several places in Europe. The name of *maltha* was first given to a bitumen found near Commagene in Syria, and Pliny says that this bitumen is so sticky that it adheres to anything it touches. For this reason he calls it *maltha*, and tells tales about it, saying that it was a great help to the inhabitants of Samozata when Lucullus was besieging it; for as soon as the bitumen touched a soldier, his armour caught fire, and there was no way of extinguishing it except by throwing earth on it, which is also the nature of other bitumens—the more water is thrown on, the more it burns.

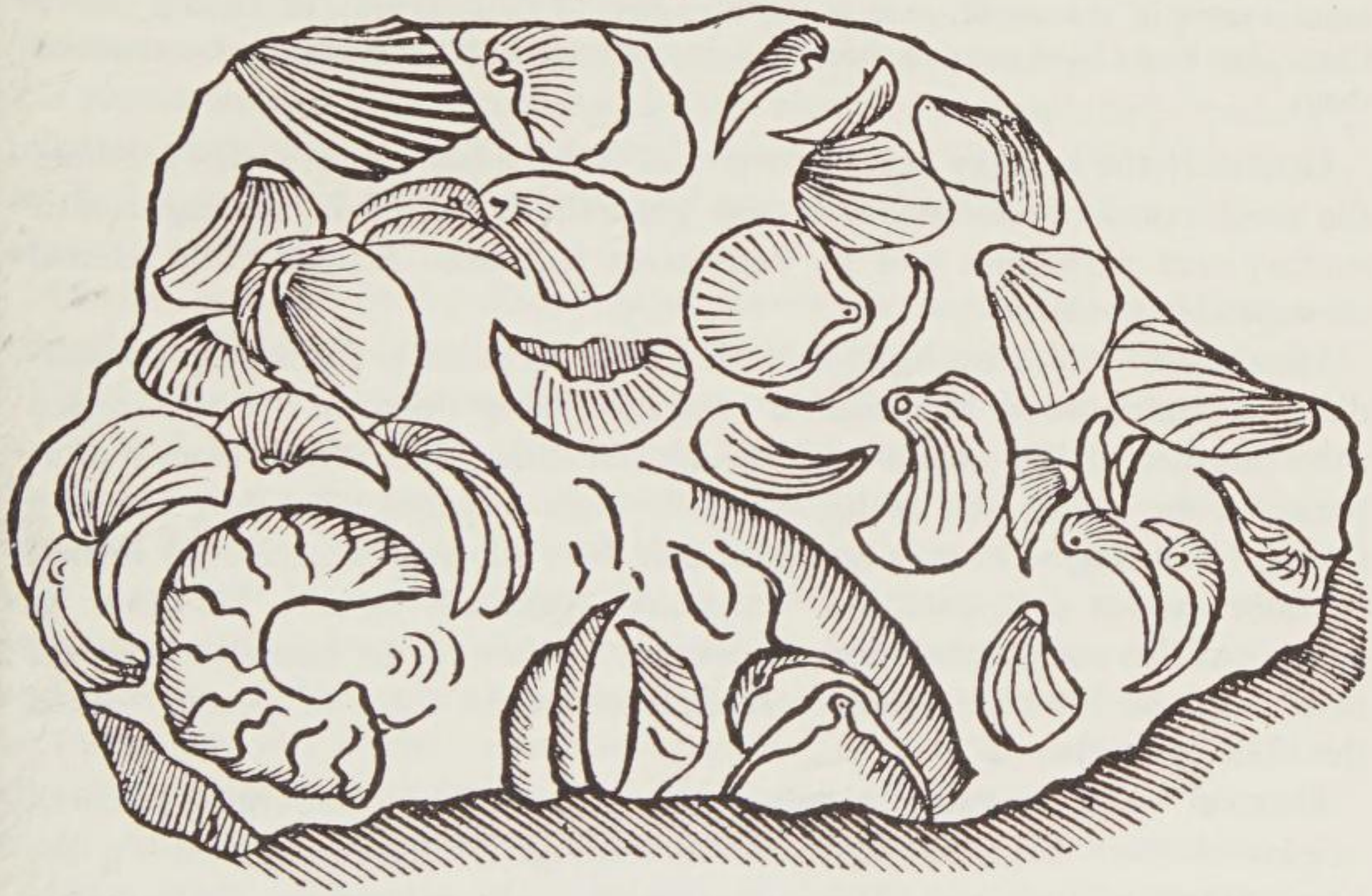


Fig. 5. Fossil shells found in bituminous rocks near Hanover by Lachmund (Oryctographia, 1669).

There is also another kind of bitumen near Ragusa in Greece, which smells like and is used in the same way as pitch, known as natural *maltha* or *pisasphaltum*, or ground pitch, but since these two sorts of *maltha* are unknown to us, and moreover are not known in France, I shall speak only of the kind which is found in Auvergne.

Auvergne bitumen is a kind of pitch with a rather unpleasant smell, which is found between Clermont-Ferrand and Rion at a place known as the Puits de Pège (Well of Pège). There is such a great quantity, that it comes out of the earth, and this causes much trouble to the passers-by, who have great difficulty in retreating from this spot owing to the strength with which it clings to their feet, so that travellers are sometimes forced to leave their shoes behind. This is the famous substance which is dried by some pedlars and then sold to spice-dealers, apothecaries and

others who have no great knowledge of drugs, as Judaean bitumen, although it is easily recognisable by the evil smell, in contrast with genuine bitumen, which hardly smells at all. It is because of this evil odour that some people call it *assa foetida stercus diaboli*, i.e. asafoetida. There are many other kinds of bitumen which come from the bowels of the earth, but as we have none of them, I shall not speak of them."

He then discusses the crude oils from Gabian and Modena, and continues:

"The black petroleum oils from Italy or Gabian are sometimes used in Medicine, but the most frequent use is by Farriers and makers of fireworks.

There are also other kinds of petroleum oils or bitumens which are found in several parts of the world, such as the bitumens of Calao (Peru), of Sirnam and of Copal, but as we have none of these, and do not trade in them, I have not mentioned them."

Gradually the analogy between the coal and the petroleum series becomes the main point of discussion. It was generally admitted in the eighteenth century that petroleum and its derivatives had been formed from animal or vegetable remains.

Lachmund [1] endorses Agricola's view that bitumen is formed by consolidation of sulphurous, inflammable substances deep down in the earth to the solid bitumen or "mountain wax" which sometimes oozes forth from mountains. Of the liquid type of bitumen one finds seepages near Burgdorf and Oberg (Hanover). There is no doubt that these substances are closely related to amber as are coal, peat and "ampelitis" (generally lignite). However he points out that rock asphalt and other impure bitumens are known to contain fossils and he identifies different shells such as the form of pecten "called the shell of St. James".

Henckel [2] was quite sure that the "mountain oils" and "mountain pitches" originated from living beings. Von Beroldingen, [3] basing himself on the observations of Eele and Clayton in England, concentrates on the fact that strata of bituminous rocks are often found to overlay coal strata. He holds that coal is of vegetable origin and was formed from peat and humus. Petroleum and bitumen are secondary products formed by distillation of coal and condensed and precipitated in higher strata. According to him there is a general relation between volcanism, salt-bearing strata, petroleum and natural gas. Independently J. R. Spielmann (1722-1783) held that bitumen was formed from vegetable remains notably the detritus of pine trees. His theory was also

[1] Dr. Fried. Lachmund, Oryctographia Hildenheimensis (J. Müller, Hildesheim, 1699).
[2] Dr. Joh. Fried. Henckel, Pyritologie und Kiestheorie (Berlin, 1725) (Engl. transl. London, 1757).
[3] Fr. Freiherr von Beroldingen, Beobachtungen, Zweifel und Fragen, die Mineralogie betreffend (Hannover, 1778).

supported by P. J. Macquer [1] who as a "phlogistonist" held that bitumen was formed from a matrix, which was itself the result of the interaction of "plant oils" and "acids".

Another school held that petroleum was of animal origin. Haquet had visited Galicia and other centres of crude oil production in 1791 and 1793 where he was struck by the common joint occurrence of salt and oil. He held that petroleum originated from the remains of creatures living in the sea. These slowly dissolved in the salt water to form petroleum, for saline strata "are permeated with sea animals and shellfish". It was evident to him that rock asphalt was finally formed by polymerisation and inspissation of petroleum. This latter contention had been amply proved by this time. Sage [2] had classified the petroleum products according to their viscosity as "naphtha", "maltha", mineral pitch and asphalt. Kirwan [3] reported that light Persian naphtha easily "degenerated into petroleum and even into pitch" and Winterl [4] was of the same opinion.

On the occasion of the discovery of elaterite (an asphaltite) near Castleton (England), Hatchett devoted an essay [5] to this new mineral, which he called "Elastic Bitumen". Here he reviewed the entire field of the origin of the coal series and the bituminous substances. His conclusion was that they were formed from the remains of both animals and plants, and that the oils, resins and fats in those remains formed the "naphtha" by decomposition. From this "naphtha" were formed petroleum–maltha–mineral tar–mineral pitch–asphaltum–jet(gagates)–pit coal by gradual inspissation, loss of hydrogen and increase of free carbon content. He was also convinced that coal could be formed by way of the series wood-peat-turf-coal. Coal, according to Hatchett, was bitumen with carbon and "earthy matter". Certain oxides of metals could combine with bitumen to form "bituminous ores" (rock asphalt).

Apart from such early scientific theories based on proper observations all kinds of fantastic stories circulated. According to one of these petroleum was the condensation product of the urine and blood of whales dropped in the Extreme North, dripping through the earth and oozing forth in Central Germany and Galicia. A Polish canon [6] in a longish essay reminds his readers

[1] P. J. Macquer, Elements of the Theory and Practice of Chemistry (London, 1758, 2 vols.).

[2] B. G. Sage, Eléments de Mineralogie Docimastique (Paris, 1772, vol. II, p. 96).

[3] Richard Kirwan, Elements of Mineralogy (London, 1784, vol. II, pp. 210, 514-521).

[4] J. Winterl, (Crell's Chem. Ann. 1788, vol. I, p. 403).

[5] Charles Hatchett, Observations on Bituminous Substances with a description of the Elastic Bitumen (Trans. Linn. Soc. vol. IV, 1798, pp. 129-154).

[6] Kanon. Ch. Kluk, Rzezcy kopalnich osoblibie zdatnicyrzych zguknaie, pogani i zagycie Warsaw, 1797).

of the "fat of the land", which formed part of the Garden of Eden. Having proved to his own satisfaction that the Garden was situated in Poland he then argues that during the Flood part of the "fat" evaporated, but the remainder penetrated into the earth and formed the matrix of the rich oilfields of Galicia.

Fortunately more sensible views on the origin of petroleum are voiced in a long article which the chevalier de Jaucourt devoted to petroleum in the famous Encyclopédie of Diderot and d'Alembert.[1] The author states that "it was formerly called "pétréol", in Italian "petroglio" and in English "petroly" or "rock-oil". It is a subtile, inflammable mineral oil, which smells strongly of bitumen and is of various colours". He then traces its history in Antiquity and goes on to say that "the Greeks called it petrelaion (that is stone-oil) or just oil. Some called it Median oil. Nicolas Myrepsos uses the term "oil of Saint Barbara", others "oil of Saint Catherine" or just "holy oil", and others "naphtha", derived from a verb meaning "to set aflame". Saint Ambrose believes the word to be derived from a verb "to attach, bind, join", because, says he, naphtha joins and unites, but this only remains true of piss-asphaltos, and the Chaldaean etymology of the word naphtha is the only true one." He continues:

"What our modern authors call Petroleum. Our modern naturalists call petroleum "naphta", "naphta alba", and "naphta nigra", Kämpf. Amoen. 274. "petroleum", oleum petrae"; "bitumen liquidum oleo simile, quod innatat lacubus".

Petroleum is a natural oil. Apart from these artificial and vegetable oils, i.e. extracted from plants by pressure, there are natural and mineral oils, emerging from the bowels of the earth on their own. They are usually called "petroleum oils" because they issue out of cracks in stone. "Petroleum" is therefore a liquid bitumen differing only in its liquidity from solid bitumens such as asphalt or Judaean bitumen, amber, jet etc. It is variously coloured white, yellow, red, green, and blackish, according to the areas where it is to be found.

It is found in India, Asia, and Persia etc. There are some hot Indian and Asiatic countries which produce petrol. A very famous and much esteemed brand is exploited in the island of Sumatra and called "miniak-tannah", which means mineral oil. A large amount of it is drawn from certain sources near Hit in Chaldea, according to Edrissi. According to Ibn Haucal it is also found in the mountains of Ferganah, in the province of Transoxane. Olearius assures us that he has seen several oil springs near Scamachy in Persia (now Shirwan in Iran), a town completely erased by a fearful earthquake.

None of the above-mentioned types of petroleum is to be found in Europe, and we only know of the French and Italian. Italy abounds in petroleum oil, found in the duchies of Modena, Parma and Piacenza.

[1] Chevalier de Jaucourt, "Pétrol" (In: Encyclopédie ou Dictionnaire raisonné des Sciences, Arts et des Métiers, Vol. XII, 1765, pp. 471-473).

Petroleum is drawn in large quantities from various wells and several springs in the Duchy of Modena, whose territory appears to be rich in this bituminous oil, but it abounds particularly near Fort Mount-Baranzon at a spot called "il Fiumetto". Wells are dug 30 or 40 fathoms deep until water mixed with oil is struck. Wells dug at the foot of hills furnish a large quantity of red oil, and those dug at the top yield

Ca.cj.

Petroleum. Lassus felix ca. de petroleo. Petroleū est oleum petre
Inuenitur autem i locis furfuris. fit ciñ cum pinguedo terre 7 aq̄ actione
caloꝛes ad igneas cóuertitur pres. Inuenitur etiam sup lapides. quod qdem per
cos resudat 7 in eis est. 7 sup mare inuenit.

Fig. 6. A seepage (After Hortus Sanitatis, edition Mainz, 1491).

a white oil, but to a lesser degree. In the same region there is an extremely barren valley belonging to the lease of Montfestin, a high rock twelve miles away from Modena and near Mounts Apennine and Gibbius, from which a spring of petroleum charged with water flows continuously; the spring is so abundant that some six pounds are drawn off twice a week.

In France we also have petroleum oil near the village of Gabian in Guyenne, not far from Beziers; a blackish oil mixed with water flows from the cracks of certain rocks and is carefully collected. It is of medium consistency, malodorans and pungent, and black in colour; it is similar to oil of turpentine coloured with black pitch. It used to be highly thought of, and constituted part of the revenue of the Bishop of Beziers who owns the rock and used to collect and trade in it, but no longer does so.

There is also talk of a source of this oil near Clermont in Auvergne at a place called the "Pège well", but it cannot be turned to good account. It is black, viscous, and malodorans."

At this point we should note that de Jaucourt does not speak of the natural gases found in several places in Auvergne and Dauphiné in France [1] and known locally as "fontaines ardentes" (burning fountains). De Jaucourt then discusses Italian petroleum:

"Study on Modena petroleum.

The only petroleum in keen demand is the Italian, especially that of the Duchy of Modena which is always the best; it is even a rare privilege to be in possession of some which is unsuspected of adulteration, for rare or little known drugs are nearly always so adulterated. Mr. Boulduc took advantage of that stroke of good fortune in 1715 to make some remarks assuredly pertinent to real petroleum the same year in the history of the Science Academy. [2]

Mr. Boulduc's remarks concern the petroleum found near Mount Gibbius. A Ferrara doctor called Francis Ariosto discovered it in 1460. Various canals were dug there at great cost and peril, through which flow three different kinds of petroleum into small reservoirs or basins."

He then quotes in full the report on the Modena oil given by Boulduc (which we will give in Chapter VII), and ends this paragraph by quoting the results obtained by Homberg [3] and Géoffroy [4] in their attempts to analyse this Italian oil, from which he infers that the medicinal properties of crude oil can certainly not be improved by distillation or similar operations:

"Mr. Homberg has shown that there are oils which ignite upon admixture of an acid concentrate. One might have expected the same result with petroleum, but this is not the case; only acid spirits dissolve completely in it and give it a very thick consistency; these inflammatory oils are the essential oils of aromatic Indian plants, and it is not surprising that petroleum does not enjoy the same properties.

Only with difficulty does it intermingle and unite with alcohol, perhaps because

[1] M. Mercier & A. Séguin, L'épigraphie et les fontaines ardentes du Dauphiné (Bull. Assoc. Franc. des Techn. du Pétrole, 1939, Nos. 48-49, pp. 77-102, 133-159) (Reprint Paris, 1939).

[2] Boulduc, Sur l'huile de pétrol (Histoire de l'Académie Royale des Sciences, 1715, pp. 19-24).

[3] W. Homberg, (Recueil de l'Académie des Sciences 1701).

[4] E. F. Géoffroy, Tractatus de Materia Medica (Paris, 1741, pars I, sect. V, cap. 1).

its consistency is too thick. Rectified alcohol, the greatest dissolvent of sulphur and oil, has no effect on petroleum, even after long digestion.

By means of distillation Mr. Geoffroy senior has drawn off an oily liquid, which, although a little more transparent, loses a lot of its smell and natural subtlety; when lit, it produces a less obscure but more listless light. On the bottom of the alembic he found only a little yellow marc.

Fig. 7. Two pictures of the "burning fountain" of St. Barthélemy du Groin (Vif, Isère).
a. From Symphorien Champier's Les Gestes, ensemble la vie du Preulse Chevalier Bayard Lyon, 1525).
b. From Jerome Monteuse d'Asti's De fonte qui flames egerit . . . (Vienne, 1523).

Mr. Boulduc was similarly unsuccessful in extracting any "phlegm" or salin spirit from petroleum by means of distillation through a steam or sand bath. Only oil came to the top, and on the bottom of the retort there remained only a very small amount of a slightly thick and brown substance; consequently petroleum may not be perfected by distillation.

Therefore when we use petroleum for medecine, it were best we left it as it is, a remedy prepared by nature like several others we have already mentioned, not to be interfered with by art."

He then turns to the crude oil of the region of Plácentia, quoting the report by Psilanderhjelm [1] in full, and concluding with these words:

"The petroleum of Monte Chiaro is clear, white and extremely inflammable. In the wells of which we have just been talking it keeps extremely well on the surface of the water, but when sealed in vessels it eats away the normally used type of stopper and evaporates to a large extent.

The origin of petroleum.

We are still sadly lacking in enlightenment on petroleum, its nature and origins; we are, however, in a position to conjecture with all due plausibility that it is the work of the fires below the crust of the earth heightening or sublimating the most subtle parts of certain bituminous matter uniting in certain soils. These parts condense into a liquid solution from the cold vaults of the rocks where they accumulate, and flow through the cracks or openings afforded by the terrane's rock formation."

He also devotes a paragraph to the discussion of the petroleum produced from bituminous rocks in Shropshire. This process applied in Eele's factory at Pitchford is very much the same as that applied at Wietze (Hanover) (see Chapter IV), but de Jaucourt considers the product obtained an inferior kind of petroleum:

"Study of alleged English petroleum.

Some Englishmen have attributed to petroleum a bituminous substance artificially extracted in their country from a blackish stone found in coal-mines. Here follows a description of it.

At Brosely, Bentley, Pitchford and other neighbouring places in Shropshire there is to be found over most of the coal-mines a rather thick stratum of rock, or blackish porous stone, containing a large quantity of bituminous matter.

This stone is carried to a workroom where it is ground down by means of horse mills similar to those used to grind stones for glass making. This powder is cast into large cauldrons full of water, and boiled so as to separate the bituminous matter from the grit, the latter being precipitated to the bottom and the former floating on the surface of the water.

When this bituminous substance has been collected and evaporated it acquires the consistency of pitch; and by admixing oil distilled from the same stone it becomes as liquid as tar. The only use made of it is the repair of ships; as it is not explosive and remains black and soft, it is properly used in preventing the setting in of woodworm.

Similar petroleum is extracted by distillation of certain soils and bituminous stones which one comes across in Germany and France.

Selection to be made in the various kinds of Italian petroleum.

The result of everything we have mentioned so far is that Italian petroleum is the only good type. The highly rated type of petroleum is new, clear, light, highly inflammable, pungent and strong smelling like sulphur. It may be counterfeited and not mixed. Those who trade in it have to take great precautions against fire, because it ignites at least as easily as gunpowder. Yellow petroleum is the most

[1] Psilanderhjelm, (Histoire de l'Académie Royale des Sciences, Paris, 1736, p. 56).

highly rated after the white, then comes red, and then green; last and least of all comes the blackish one, which is considered too crude. Use to which petroleum is put.

In some parts of Italy it is customary to use crude petroleum instead of oil for purposes of lighting; quite a lot of it is also used by smiths and makers of fireworks. The only present use which Persians make of petroleum, according to Kämpfer, is to thin their varnish."

The last paragraphs of this excellent matter-of-fact survey of eighteenth-century knowledge of petroleum are devoted to its medicinal properties, about which the author has serious doubts which we will discuss in detail in Chapter VIII.

De Jaucourt tells us that Vossius, the famous Leiden professor "wrote a learned dissertation on the ancient and modern naphtha", but unfortunately the bibliographies of both Gerard I. Vossius and Isaac Vossius do not mention such an essay, and it is quite possible that it was never published. May be the essay by Isaac Vossius on the origin of gunpowder is meant (Variarum Observationum Liber, Leiden, 1685, pp. 86-94) which gives some references to the use of petroleum in ancient warfare and as a constituent of types of Greek fire used by the pirates of the Far East in the days of Vossius.

A systematic survey of the bituminous substances then known is found in the same Encyclopédie under "Asphalte" (Vol. I, pp. 758-760) and "Bitume" (Vol. II, p. 267). There we are informed thus:

"*Asphalt*, "asphaltus, tum".

This name has been given to Judaean bitumen, because it is taken from Lake Asphalt; and in general all solid bitumen carries the name of asphalt, such as for example the bitumen found in Switzerland at the beginning of the century, etc.

The "asphalt" of the Greeks is the Roman "bitumen". Judaean bitumen is solid and heavy, but easy to break. Its colour is brown and almost black; it shines and is of a highly resinous hue, especially when heated: it ignites easily, and melts in fire. This bitumen is to be found in several places, the most highly rated coming from the Dead Sea, otherwise called Lake Asphalt, in Judaea."

After a discussion of the destruction of Sodom and Gomorrah and the formation of "wells of bitumen" according to Gen. XIV, we hear:

"One is led to believe that a large quantity of bitumen emerges from the asphaltic lake, rising to the surface and floating. Originally it is liquid and so viscous that it is hard to remove; but it thickens gradually, becoming as hard as dry pitch. It is said that the penetrating, pungent smell given off by this bitumen is most injurious to the inhabitants of the area, and shortens their life-span; that all birds flying over the Sea fall dead into it, and that no fish live in its waters. The Arabs collect this bitumen when it is still liquid in order to tar their vessels.

They call it "Sodom karabeh", "karabeh" often meaning "bitumen" in their language. The bitumen of Lake Asphalt has also been called "funeral and mummy gum", because the Egyptians used this bitumen and pissasphalt to embalm their dead. Dioscorid says that real Judaean bitumen is a brilliant purple, and that black

bitumen mixed with foreign bodies shall be rejected: and yet all the bitumen we have nowadays is black: but if broken up into small pieces and the fragments looked through, a slight saffron yellow tint is discernible, which is perhaps what Dioscorid meant. Pissasphalt hardened by heating in copper or iron boilers is often given out as real Judaean bitumen. This bitumen might also be confused with Stockholm black pitch, because it is coloured a very shiny black; but it is not as hard as Judaean bitumen, and like pissasphalt has a pungent odour which makes it easily recognisable."

We are then given a long description of the asphalt quarries of Val de Travers and Lampertsloch (Pechelbronn), in which the name of Eyrinis is missing, and in which we hear of M. de la Sablonnière only. We are told of the seepage at Lampertsloch, which yields some 10-12 lbs. of oil a day, though slightly more in summer than in winter. The most interesting part of the article, however, is the last where we are informed of the strata found in the galleries of Pechelbronn near Lampertsloch:

"Mr. de la Sablonnière had a forty-five foot deep draining-well dug one hundred and twenty fathoms north of this source, and lined with oak-wood; he came across several not very rich asphaltic or bituminous veins, the last at forty five feet being very rich, horizontal, but with an undulating upper surface; that is to say in some places it is six foot thick, and in others less than one, after which it increases; the base is in a straight horizontal line on its West-East axis, but dips from south to north. The upper surface is made of a one foot thick type of flat slate-leaved rock, and clings to a clay rather similar to serpentine.

In the bottom layer there is a reddish sand containing a less black, purer and more fluid oil than that of the mine, yet enjoying all the same qualities; like the rock above the ground, this red sand serves to produce petroleum oil, having the same colour.

In order to give some idea of this mine, it is necessary to mention that it is vast and exposed within a range of eighteen miles; since 1740 when Mr. de la Sablonnière began working it in one bed alone, now approximately sixty feet below ground level, an area of one eighth of an acre has not yet been exhausted, and the three beds or layers above that actually being worked have not been touched; this bed is over sixty feet higher than that discovered below the "backelbronn" seepage, where there are two beds in between; but there is every indication that more than one hundred feet below this last bed, there are several more and richer layers; this conclusion is arrived at by what was discovered with the drilling and by the oil carried at the bottom of the source; the marcasites are the same, charged with sulphur, bitumen, and tiny copper particles. Furthermore a few fragments have been discovered there, leading one to suppose that heavy seams will be discovered as one goes deeper.

Should the work go on as planned and the rock far below be reached, it is hoped to find a very rich copper and silver mine, for the marcasites are the same as those of Sainte-Marie-aux-Mines.

It has been observed that the bitumen in these mines renews itself and continues to flow in the old galleries which have been emptied of ore and filled with sand and other rubble; this bitumen pushes its way up and not down, which makes one assume that it is a sulphur vapour forced up by the central heat; it penetrates sand

more easily than clay, and flows everywhere it can with the water, with the result that the richer the seam the more one is hampered by the springs. In order to remedy this costly drawback Mr. de la Sablonnière has just decided to change the direction in which he has been working; up till now his galleries have run from south to north, and he is having built north to south parallels; in this way his costs will be far less, because the mine dips to the north, and by following a southern direction the water will flow of its own accord into the draining-wells. All the galleries made so far are four feet wide, six feet high and have a canal underfoot some three feet deep for water drainage. These galleries are all lined with young oak wood from eight to ten inches in diameter, and the canals are boarded over to enable the workmen, who work day and night, to wheel their barrows without difficulty. The barometre everywhere reads the same as in the Observatory cellars. There has sometimes been a lack of air deficiency made good by means of large bellows and a two hundred foot long tinplate pipe for conducting outside air to the furthest part of the galleries. For the past three months a sump has been completed north, allowing air to circulate throughout the galleries.

In order to extract from this mine a kind of black grease used for greasing all the mechanism, the only method is to boil the sand of the mine in the water for one hour; the grease rises, and the sand remains at the bottom of the boiler. This grease is placed without water into a large copper boiler to improve in quality and allow any moisture remaining from the first operation to evaporate.

A black, liquid, flowing oil—petroleum oil—is extracted from the rock and its red earth; this operation is carried out by means of a five or ten to twelve hours. The ore or rock are placed in a large iron and well luted furnace, and slip down by force of gravity. These oils can be produced in large quantities. It is this oil preparation which Mr. de la Sablonnière intends to use for the maintenance of ships.

Red and white oil are extracted "per ascensum", and are very useful in medicine, especially in surgery, for the curing of ulcers and all skin diseases."

The entry under *bitume* finally gives us a description of the bitumen species in these words:

"*Bitumen* m. (Nat. Hist.) inflammable matter belonging to the mineral world, to be found in earth and water under various forms, and divided into solids and liquids. The liquids are naphtha or petroleum, pissasphalt or mineral pitch, etc., the solids are Judaean bitumen, ambergris, yellow amber, jet, and mineral coal. Petroleum and pissasphalt are to be found in water. See Petroleum and Pissasphalt. The others are taken from the ground. See Amber, Jet, Asphalt etc. Although they are all of a rather hard consistency, it has been proved that they started off as liquids, and that they only hardened with the passing of time. Only oils can dissolve solid and mingle with liquid bitumens. In the main they are formed naturally, and almost unadulterated: when it happens that they are enveloped in foreign matter, artifice has to be resorted to in order to remove the foreign bodies enveloping them. Sulphur and arsenical cones are placed in the same category as bitumens, because they enjoy nearly all the same properties, and their nature is more analogous to bitumen than to any other body."

Further remarks on the origin of crude oil are made in the article on *Naphte* (Tome XI, p. 15, edit. 1774) in the following words:

"*Naphtha* is what Naturalists call a white, transparent, very fluid and light bitumen which floats on water. This substance is so highly inflammable that it can ignite at a distance; it has a penetrating odour and burns without leaving any residue.

It is very rare to find naphtha as pure as this; the substance currently called naphtha is of a more or less light yellow; that is to say the colour of succin (resin), in which case it does not look as pure as the perfectly white one.

Naphtha owes its origin to buried resinous trees, as well as other bituminous substances, mineral coal, jet, yellow amber, etc. The only difference is that the substance producing naphtha seems filtered, melted and, as it were, distilled within the soil. Indeed, this bitumen has a close connection with the essential oils which are chemically extracted from certain plants. Mr. Rouelle believes that the purest and clearest naphtha comes from succin: according to this learned chemist underground conflagrations do not always appear to have explosive symptoms, but often remain low and without causing eruptions below ground; then they can distil and as it were, rectify the solid bituminous substances within it, liquify them, force them to seep upwards and out through the layers of soil and stones; this new substance subsequently appears in the form of naphtha, that is to say of a thin, light oil sometimes found floating on the surface of thermal water.

This highly probable conjecture seems to be confirmed by several facts. Indeed, we learn that in the neighbourhood of Astrakan, in order to obtain naphtha, one need only dig wells which immediately fill up with this bituminous liquid. In that country it is used in place of oil to burn in lamps, and even in place of wood, which is very rare, for heating and cooking. In order to achieve this all one has to do is to throw a few handfuls of earth on to the fireplace, soak it with naphtha and set fire to it: it lights immediately; and provided always that one keeps stirring the mixture, one contrives to cook meat more quickly than with wood. It is true that in this way the interiors of all the houses are covered in lamp-black and filled with a smell repulsive to all except Tartars.

Three miles away from these naphtha wells is a place called Baku, where the ground burns perpetually. It is an area approximately three quarters of a mile in extent; the ground is not visibly alight; to see the fire one has to dig a six-inch hole, and if a wisp of straw is introduced it will catch fire immediately. Gaurs or Persians who worship fire and Zoroasterians come here to pay homage to their god whom they adore under the emblem of fire. Those are the everlasting fires of Persia; they are peculiar in that as they burn they do not give off any smell and leave no ashes. This detail is taken from a German letter dated 2nd July, 1735, in Astrakan, and inserted in a work by Mr. Zimmermann called "Mineralogical Academy".

Naphtha is also found in several places in Persia, China, and Italy, especially in the environment of Modena. It is also found in Germany and France, but rarely enjoys the limpidity and transparency of the purest naphtha."

The well-informed surveys in the Encyclopédie surpass by far the information which one can gather from the eighteenth century economists. Even a well-informed author like Johann Beckmann [1] seldom achieves more than a

[1] Johann Beckmann, Beyträge zur Oekonomie, Technologie, Polizey und Kameralwissenschaft (Göttingen, 1779-1791, vol. III, p. 195). — Physikalisch-ökonomische Bibliothek (Göttingen, 1770-1808, vol. XX, p. 342).

few lines on local production in Hanover or Seefeld, and neglects the opportunity of discussing the possibilities and future of the various "oil-fields" of his days.

There is little sense in surveying all the fantasies that circulated during the eighteenth century on the origin of petroleum. More important is the fact that we find the scientists of those days seriously discussing the theories of both vegetable and animal origin, backed by appropriate observations. Both theories were to be elaborated during the nineteenth century when further developments of chemistry and geology brought further proofs. That century also saw the rise of the "carbide" or "mineral" theory which held petroleum to have been formed by the reaction of water on carbides in the earth, the gases evolved polymerizing to yield petroleum.[1]

The relationship which some scientists believed to exist between petroleum and coal was to be of great importance for the development of the petroleum industry in Europe during the nineteenth century. On the strength of it shafts and boreholes were sunk near seepages and veins of bituminous rocks on the earth's surface. They were believed to lead men towards the lignite and coal strata where the oil or bitumen had originated. In practice they led to the better understanding of the structure of oilfields and the establishment of local production in several European countries. Notably the association of oil and salt domes was to prove valuable evidence for the discovery and exploitation of future oilfields.

The composition of crude oil was to remain a closed book as long as bituminous substances were still mainly used as such for lubrication, fuel or lighting, waterproofing and roadbuilding or for medical purposes. Differentiation of their application brought with it a clearer study of crude oil's nature and composition.

[1] Berthelot, Compt. Rendus, Vol. 61, 1866, 949.

CHAPTER FOUR

THE OIL SEEPAGES OF HANOVER AND THE FIRST OIL WELLS OF EUROPE

The most important oil resources of modern Europe are found in the plains between the Elbe and the North-Sea, but although several of them were known in the past, their history does not go back as far as those of Tegernsee or Modena. The earliest reports are found in Agricola's essays [1] which mention oil seepages "near the famous town of Brunswick", "two miles from Brunswick along the road to Schöningen, and in swampy sites about three miles from Burgdorf"; that is to say he knew the present oilfields of Reitling and Hänigsen. He tells us [2] that "the Germans in Transylvania and Lower Saxony inspissate the crude oil by boiling in copper or iron pots. In this process it easily ignites but the fire is extinguished with wet linen towels . . . According to Pliny a mixture of wood tar and petroleum is an excellent medicine for cattle scabies and inflammations of the udder. The Saxons make old cart grease smoother by adding crude oil, but others prefer wood tar." Again "in Lower Saxony the peasants not only use the oil in lamps but also make marriage-torches by dipping dry stems of the great mullein in it, besides lubricating their carts with it. They use it also to paint wooden posts to protect them from the effects of rain." [3]

Production remained on a local scale in these regions until well into the eighteenth century, when further information appears in the technical and geographical handbooks. The crude oil was skimmed from the water of wells or was prepared by the combination of smelting and cracking, which the ancients called "destillatio per descensum". Both methods are described in Agricola's De Re Metallica. [4] Thus we learn that the asphaltic limestones of Westphalia were the object of thorough investigation by the authorities in Münster from 1772 onwards, but that the strata at Darfeld, Büldern, Hangenau and Appelhülsen proved unsuitable for economic exploitation at that date.

[1] G. Agricola, De natura eorum quae effluunt ex terra, 1545 (Opera 1657, pp. 535, 538).
[2] G. Agricola, De natura fossilium, 1546 (Opera 1657, p. 595).
[3] G. Agricola, De natura eorum quae effluunt ex terra, 1545 (Opera 1657, pp. 542-543).
[4] G. Agricola, De Re Metallica, 1556 (Opera 1657, pp. 468-469).

The Hanoverian seepages near Hänigsen were, however, exploited, according to the physician Johann Taube, [1] who visited them in 1769. He tells us that:

"This thicket is surrounded by an embankment of earth not unlike a rampart thrown up centuries before. For a considerable distance around this rampart there is the usual poor meadowland interspersed here and there with marshy places. On the Oppershagen side it borders on a fairly wide expanse of sandy heathland with a few low thickets. The inhabitants of Hänigsen are tenants of these tar wells and collect the tar as soon as the good weather comes in spring, paying a certain rent to the local authorities at Meinersen. The depression in the bushes referred to above is

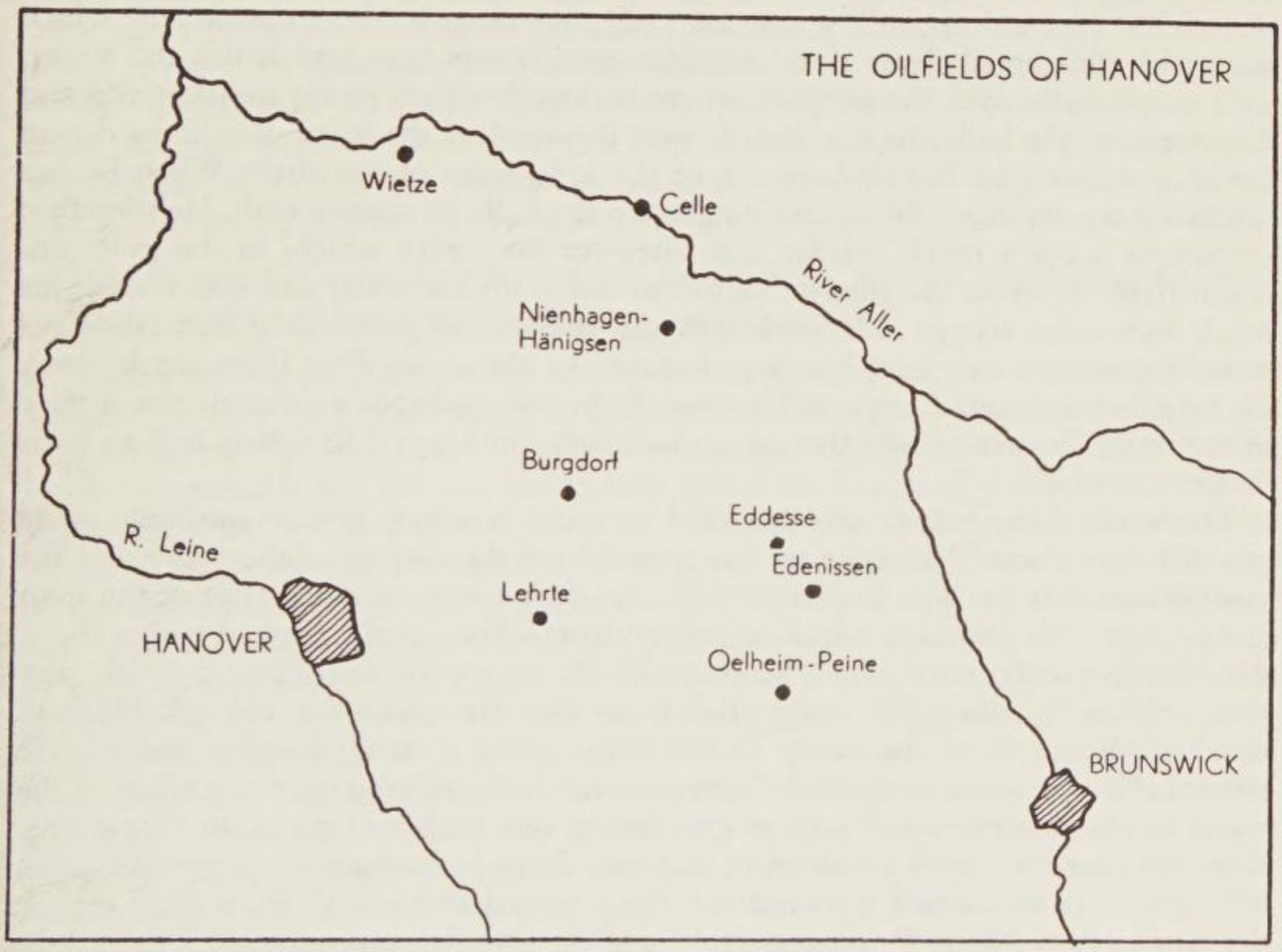


Fig. 8.

divided into three sites, which the inhabitants call "Kuhlen" or pits, and in which each family has shares. In these pits various wells have been dug and poorly timbered on the inside. These are called "Hohlen" and I counted five in the first pit and ten in the third. These shafts are oblong in shape, the longer side measuring about six feet and the shorter four feet. They become narrower towards the bottom and, measured from the surface to the sandy floor, are from eight to nine feet deep. I do not give exact dimensions here, since they all vary both in breadth and in depth. Even the narrowest, however, are wide enough to permit a man to stand on the

[1] J. Taube, Beiträge zur Naturkunde des Herzogtums Lüneburg (Celle, 1769, Zweite Abt., p. 28 ff.).

bottom, although with some difficulty. These shafts are so timbered with deal boards that the person wishing to collect tar can climb down as though on a ladder, albeit a very uncomfortable one. All these wells are constantly full of water, which, apart from the usual peaty taste, has a very unpleasant tarry flavour. All the other springs of this whole region have practically the same taste and for people unaccustomed to it this water is scarcely drinkable. It even affects farm animals, for the bacon from pigs fattened here is quite yellow and smells and tastes of it.

Whenever the tar is to be collected the shafts have to be almost completely emptied of water. This task is called bailing. A large deep wooden ladle is used to bail out the water over the edge of the shaft on to the ground and into a narrow channel. This leads into a deep hollow not far away and close to the embankment which surrounds this small depression. Another man stands here and ladles the water, as it accumulates over the rampart, where it runs down on to the meadowland and disperses. As the bailer in the shaft lowers the level of the water he climbs down, lowering himself by the timberwork of the long sides of the shaft. When he has reached a certain depth he can no longer use the ladle he started with. He therefore exchanges it for a much smaller and narrower one, with which, in the most uncomfortable position imaginable, he has to scoop up the water and toss it over his head. But some always falls back into the shaft, thus prolonging this laborious task. When the water level has been lowered to about one foot from the bottom, the tar flows through the spaces between the boards and accumulates on the surface of the water. In some shafts this takes place very quickly and in others half an hour is often required.

The workers cannot say whether cold or warm weather, rain or sunshine, make any difference here. When the tar has spread over the surface of the water and the worker sees that the flow has stopped for the time being, he climbs out of the shaft and returns with a basin in which to collect the tar. He is also equipped with a short, flat, wooden scoop with which he skims all the tar on the water into a corner and then collects it, tilting the scoop slightly so that the water can run off. He then transfers the tar from the scoop to the basin, using a small wooden scraper. He repeats this operation until all the grease which had gathered on the surface of the water has been removed. He thereupon leaves this shaft and starts on a new one. It is said that the yields obtained in this way from each shaft are never the same, but vary from about half a pound to over a pound and a half. Each shaft can be drawn or rather "bailed" twice a week; a strong worker can complete this task in about 2 hours. The water seeps through again, filling the shaft to surface level in less than twelve hours. Near these wells each tenant has a crude hut roofed with turf in which he locks up the clothes he uses for this unpleasant work and his store of tar. When the tar has been skimmed off the surface of the water and collected in the basin, it still contains many impurities such as water, earth etc. To remove these each worker has in his hut a cask which has many small holes bored in the bottom and sides. The newly won tar is poured into this and runs through the small perforations into another cask standing underneath. It is then sold for use at the price of 3 Marien-Groschen per pound. The waggoners of this region prefer it to the processed tar as they find that it is greasier and leaves less solid deposit. On the bottom of the tar springs there is clear white sand from which no tar can be obtained by washing and stirring in the water. The wells, therefore, must not extend as far down as this layer of sand but should end just a small distance above it; they should

not absorb or become contaminated by it, as occurs in the tar wells of Wietze.

On the rampart surrounding these wells lie many lumps of agglutinated sandy clay which is identical with the "hard earth" found in the tar wells at Wietze, except that it contains several coarser types of sand. On the heath and meadowland there is nothing to be seen but the common and ubiquitous herbs. No fossils occur apart from the eschara Corallina and Corallia Erica Wallerii, both fern-shaped.

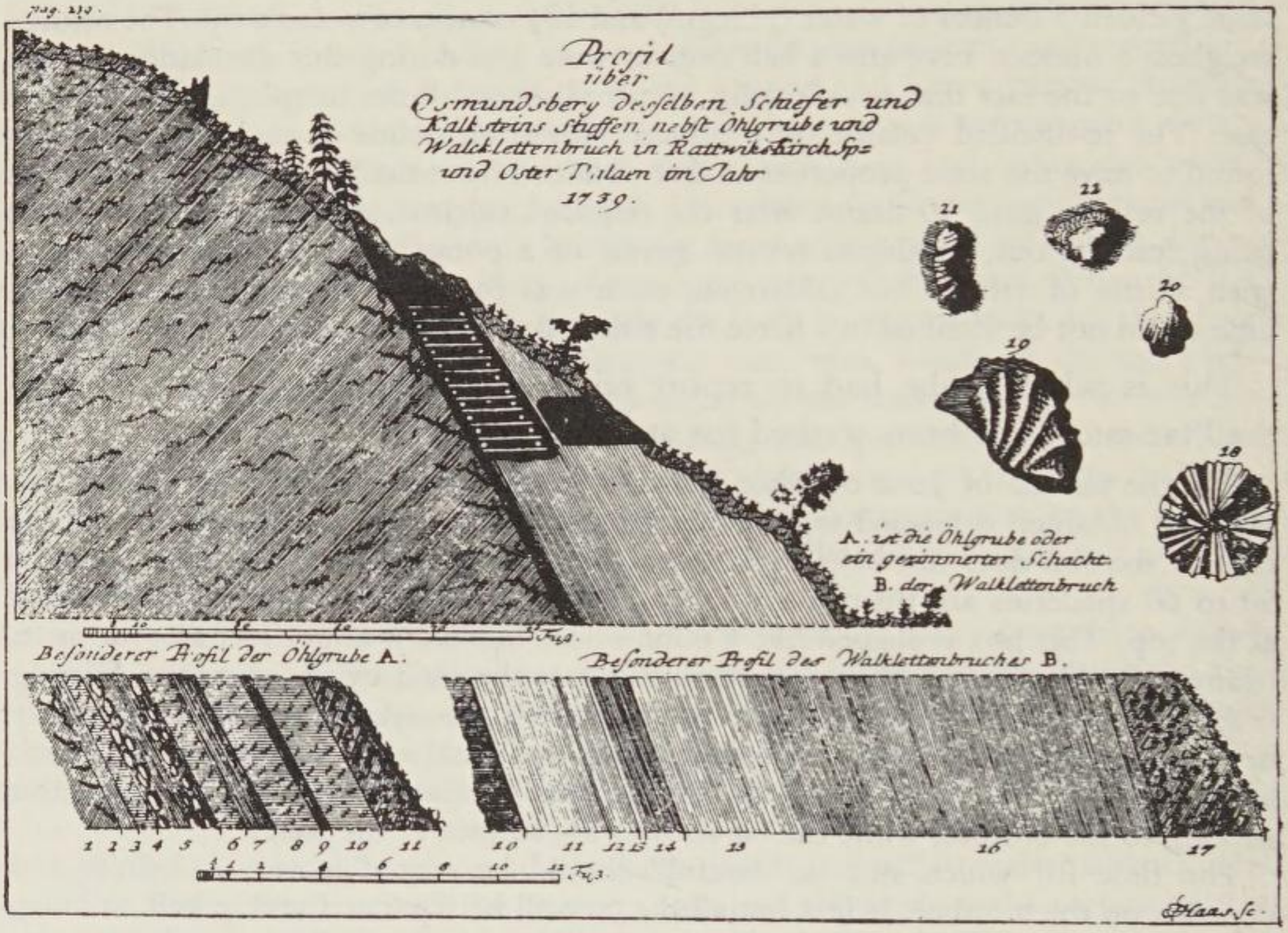
A chemical examination similar to that carried out on the tar found at Wietze showed a marked difference to exist between the two. Thirty-two ounces of the same yielded 5 ounces of water (phlegm) and 13½ ounces of volatile oil. The residue weighed 8 ounces. Five and a half ounces were lost during this distillation, which was due to the fact that overflowing occurred several times in spite of the greatest care. The re-distilled volatile oil produced almost an ounce of naphtha which was found to have the same properties as that obtained from the Wietze tar. Four ounces of the residue gave 10 drams after the required calcination. Seven of these, after being leached out, produced several grams of a potassium salt which effervesces with spirits of vitriol. No calcareous earth was found. 3 Drams of the calcined lime could not be vitrified in a fierce fire either alone or with borax or salt of tartar."

This is what Taube had to report on Wietze, where, according to him, the "tar sand" has been washed for at least a century:

"In the middle of June or when it is the dry season, digging is started and the tar sand obtained is heaped together and immediately covered with turf so that the heat of the sun does not bake it. When a sufficient supply has been collected some 50 to 60 spadefuls are thrown into a box about ten feet long and four feet broad at the top. This box is shaped like a punt whose bottom is about half as wide as its beam. Enough water is then poured in to cover the sand by about a foot. Stirring is then started. This is done with the iron-tipped wooden spades which are customary here. Seven or eight people constantly agitate the water and sand with these, much in the same way as an egg is beaten. The tar is then released from the sand, the latter sinking to the bottom, while the tar rises to the surface of the water.

The time for which such a "boxful" should be stirred is very indefinite and depends on the weather. If it is hot all the tar will be separated within half an hour. If it is rainy and cold almost twice as long will be necessary. One can tell from the colour of the sand whether it still contains any tar. For whereas it was previously dark grey with a somewhat blueish tinge, it becomes quite white after stirring. The tar which has accumulated on the surface is skimmed to one end with a board of about the same width as the box. Wooden ladles are then used to transfer it into large tubs, which are subsequently emptied in the owner's farm into a container lined with stout boards and shaped like a well shaft. Here any remaining sand and water settles out within 24 hours and the tar is kept until sold. There is still a large amount of tar left in the sand after the first extraction. Each box is therefore stirred twice and almost as much tar is obtained the second time as the first. This profitable yield has prompted the inhabitants of the surrounding region to search everywhere for these tar deposits. A villager from Steinföhr, which is quite near Wietze, has recently succeeded in finding a layer of tar sand in one of the meadows on his farm and has started to exploit it equally advantageously. This very extensive meadow is swampy throughout and the tar vein lies only one foot or at the most two below the surface. I noticed, however, that at the time it was not so thick and that the sand

did not appear to be so rich in tar as that from the old pit. When digging and searching for good sand the workers often come upon a layer of what they call "hard earth". This always covers the useful layer. But because tar cannot be extracted from it by the usual process, it is cast aside as valueless and in a short time becomes quite hard and loses its dark colour to a great extent. This "hard earth" has not yet been discovered in the new pit at Steinföhr; this may be due to the low-lying and damp situation of the meadow. In both pits, or rather sites where tar sand is obtained,


Profil
über
Osmundsberg desselben Schiefer und
Kalksteins Stuffen nebst Öhlgrube und
Walcklettenbruch in Rattwikskirchspe
und Oster Tilarn im Jahr
1739.
A. ist die Öhlgrube oder
ein gezimmerter Schacht.
B. der Walklettenbruch
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Besonderer Profil des Walklettenbruches B.
1 2 3 4 5 6 7 8 9 10 11
10 11 12 13 14 15 16 17
Haas sc.

Fig. 9. Washing "mountain-oil" from the oil-sands of Osmundsberg (Sweden) according to Tilas (Abh. K. Schwed. Akad. Wiss. 1739/1740, Vol I, page 239, Hamburg 1749).

a large number of trunks, branches and roots, mostly alder, are found. These are very heavy when dug out and have the full smell of tar. However, if they are dried in the air and the sun they become light and will burn with a bright flame like resinous pine-wood. The tarry smell is also completely lost in the drying process and only a musty odour is retained.

In order to ascertain how rich in tar this sand was, I placed two ordinary pounds of it in 6 pounds of pure, cold water and stirred it until everything had separated out. The following morning I removed the floating tar as carefully as possible and found that it weighed 2½ ounces, not counting that which had adhered to the implements. Each pound contains, therefore, at least 1¼ ounces of pure tar. Out of curiosity I carried out a test under the same conditions in order to find out whether the sand which had been washed by the workers still contained any tar, and to verify their

assertion that everything useful had been washed out. After 2 pounds of this sand had stood overnight in 6 pounds of water there was so little tar on the surface that it was impossible to skim it off.

My attention was next claimed by the "hard earth" which was considered to bear no tar. I reduced 2 pounds of this to small fragments, placed them in 6 pounds of cold water and allowed them to stand for 24 hours, stirring the mixture frequently. At the end of this period, the water was clear and had had no effect at all on the earth. On the surface there were small globules of tar, like grease, which weighed scarcely 20 grams. I let this water stand for three weeks, stirring it several times each day, but no further decomposition took place. It did not even acquire a tarry flavour. I thereupon broke up another 2 pounds of "hard earth" and placed it in a vessel containing boiling water. Everything now dissolved as soon as I stirred. The grease rose to the surface, while a grey and still rather sticky and fatty sand was deposited on the bottom. When everything had cooled I found I had somewhat more than half an ounce of a hard, tough material which displayed all the properties of mineral pitch, bitumen terrae tenax, or asphaltum solidum.

I now also wished to discover the ingredients of the tar by means of a chemical examination. I heated 32 ounces of the finest tar, without any admixture, for 20 hours in a retort over a hot fire. The first product was a watery fluid (phlegm) which weighed one and a half ounces. There followed 11 ounces of a light-coloured and very penetrating oil. When the heat of the fire was increased I obtained a further 9 ounces of a dark, equally strong oil which had a rather burnt taste. When nothing more could be given off the residue weighed 8 ounces. The 2½ ounces not recovered partly escaped as vapours and were partly left adhering to the vessels. The examination shows this tar to be very rich in rock oil (petroleum), for the 20 ounces which were distilled are nothing else. The tough material left in the retort is a genuine mineral pitch, bitumen tenax Wall., gagates, ampelites and is similar to that obtained by leaching out the "hard earth" with hot water, except that it is more friable, because there is rather more petroleum in that which is leached out.

4 Ounces of the residue from the distillation were heated for 2 hours in a crucible, after which 1½ ounces were left. When half of this earth had been leached out and boiled down, it yielded several grams of a salt which effervesced with oil of vitriol and is therefore a true potassium salt.

The other half was left for a further 3 hours in the hottest fire. However, it refused to glaze either on its own or with the addition of borax and potash. The two oils which had already been once distilled were now redistilled. The first product was a very fine, white, and volatile oil weighing more than 2 ounces. The other was again a much purer petroleum, both in colour and in taste. Half an ounce of this quickly and completely dissolved a dram of copper. The fine, white and volatile oil is a genuine naphtha, for it catches fire very easily and burns away quickly and completely in water without leaving behind the slightest trace of soot. It also absorbs gold dissolved in aqua regia, taking on a beautiful colour in the process, and does not precipitate it again."

The "tar-water", says Taube, has excellent veterinary qualities, it cures frozen legs, kills insects and will protect fur. These lines repeat the old folk tradition on the medicinal properties of petroleum, which we will discuss later (see Chapter VIII).

This local production seems to have prospered, for a generation later Patje [1] gives us a similar report on Edenissen and tells us that this oil was sold for 2 Groschen 2 Pfennige per pound, mostly for veterinary purposes. This method of washing the oil from bituminous sands reminds us of Eele's roughly contemporary "bitumen factory" at Pitchford (Shropshire). [2] Here the bituminous stone was extracted from the hill-side and the ground. It was then boiled with water in copper pans, the oil skimmed from the surface, collected, and finally distilled to obtain the "pitch". The distillate was used to correct the consistency of the pitch which was then sold as a substitute for the Swedish tar used in careening ships. The distillate "resembled turpentine or oil of petre and several persons have used it with great success against pains and complaints". It was sold under the name of "Betton's British Oil". This factory was built on the Severn near Brosely, where bituminous outcrops are found with coal strata in the nearby hills. We do not know for how long this bitumen factory operated, but its methods closely resemble those of Wietze.

A more efficient method of washing the crude oil from oil sands was applied in Sweden. Tilas [3] reports that running water was used there to produce crude oil from galleries cut into the rocks bearing strata of "tar sand".

The methods of production had not changed when von Veltheim [4] visited this region in 1809. He tells us that oil-seepages ("tar-wells") were exploited on Reitling common east and south-east of Brunswick on the road to Königslutter and Helmstedt. The "tar" collected in hot sunny weather in little pools and ditches of water formed where clay had been dug. The inhabitants of the nearby villages used this tar as a lubricant for their carts and to cure cattle ailments. Koch of Helmstedt started collecting this oil on a larger scale in 1796 by sinking two shafts. One of these was a failure and was later filled in. The second yielded a fair supply of oil at a depth of 40 feet. Koch quarreled with the villagers who regularly skimmed oil from the water of the shaft, the production of which gradually decreased. In the year 1804/5 it produced 177 barrels (of 30 pounds each) which were sold at $1\frac{1}{2}$ Thaler per barrel. In the year 1805/1806 production was 121 barrels which were sold at 1 2/3 Thaler each. More shafts were sunk in the neighbourhood, one of which

[1] Cammermeister und Commerzrath Patje, Kurzer Abriss des Fabriken-, Gewerbe- und Handlungs Zustanden in den Chur Braunschweig-Lüneburgschen Landen (Göttingen, 1796).

[2] Martin Eele, An account of the making of pitch, tar and oil out of a blackish stone in Shropshire (Phil. Trans. vol. XIX, 1697, p. 544). See also: Brit. Patent No. 330 of 1694 (Eele, Hancock & Portlock) and page 40.

[3] D. Tilas, Mineralgeschichte vom Osmundsberge in dem Kirchspiel Rätwick und Ostdalen (Abh. Königl. Schwed. Akad. vol. I, 1739/1740, Hamburg 1749, page 239).

[4] Freiherr von Veltheim, Über ein bisher wenig beachtetes Vorkommen von Bergtheer in Nord-Deutschland (Archiv f. Mineralogie, Geognosie, Bergbau u. Hüttenkunde 1839, pp. 174-177).

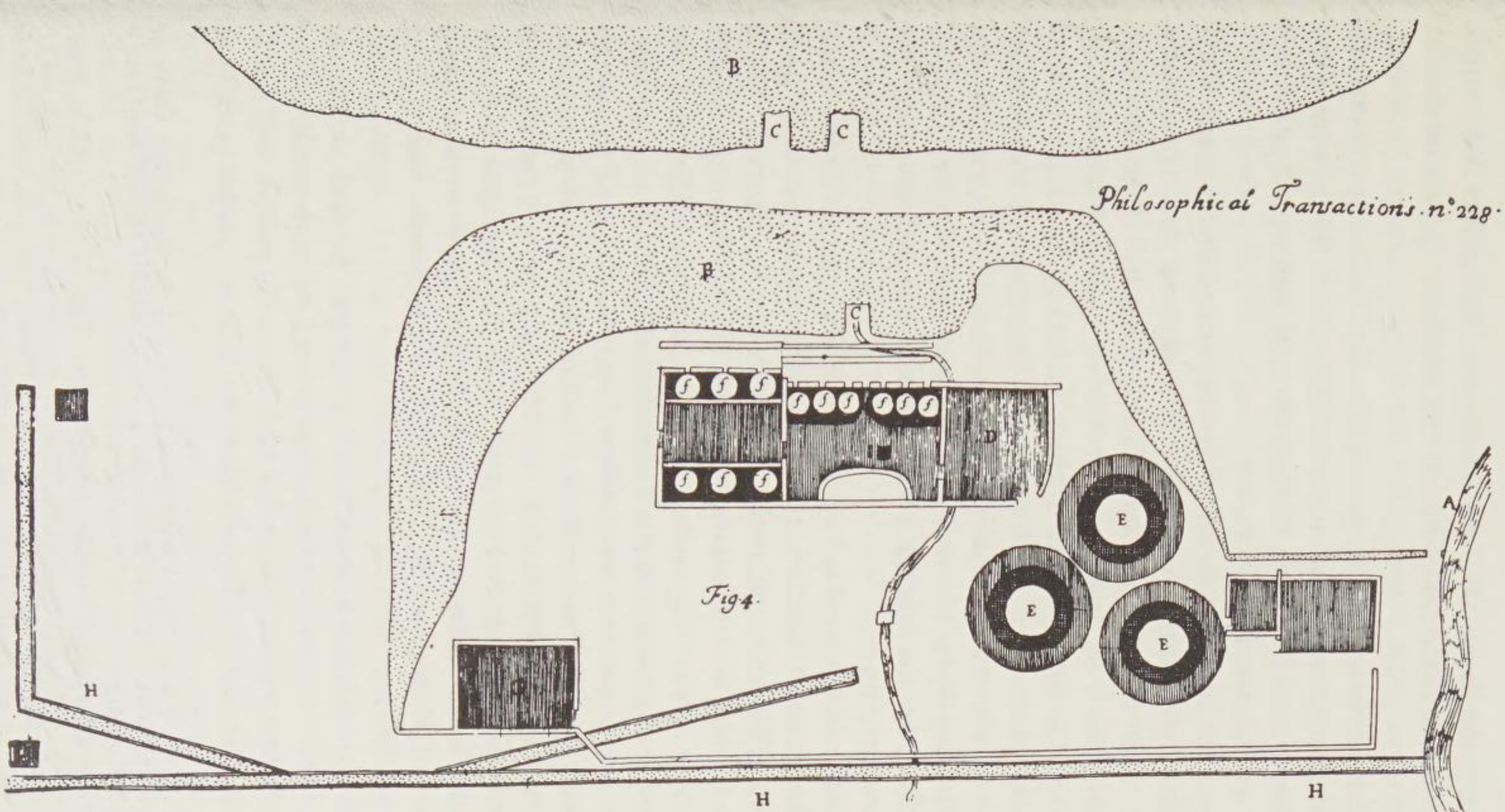


Fig. 10. Plan of Eele's "Bitumen factory" at Pitchford (Shropshire) A. River Severn. B. Rocks containing coal-strata. C. Quarries from which the bituminous rock is taken. D. Storage. E. Querns for grinding the rock. F. Stills in which the rock is boiled with water G. Stillhouse (After M. Eele, Phil. Trans. vol. XIX, 1697, Page 544).

struck limestone at a depth of 119 feet. From the black strata above this limestone the oil oozed into the shafts but in much smaller quantities than at Reitling.

However, conditions were to change rapidly for the early nineteenth century was to witness extensive drilling activities, which the governments of the German States carried out when looking for coal, lignite, salt and other useful minerals to strengthen their economy.

It is a well-known fact that oil was struck in the United States many years before Drake deliberately drilled for oil. This happened fairly frequently when early in the nineteenth century men drilled for salt.[1] Thus at Duck Creek near Marietta (Ohio) oil was struck at 475′ in 1814 and was sold. In 1833 this well produced a barrel per week, which fetched 50-75 cts. per gallon. The same thing happened when the Hanoverian Secretary of the Interior ordered a thorough survey of the subsoil of the kingdom in order to study the possibilities of exploiting layers of marl, lime, gypsum, salt, lignite and coal. Blumenberg[2] studied the documents very carefully but unfortunately his study never appeared in print.

Hahse, the inspector of salt works, had urged the Secretary of the Interior to drill for oil, in his letter of March 6, 1853. This maintained that wells sunk near the "tar-wells" of Wietze would definitely lead to the lignite strata where the petroleum was formed by fermentation or heat, for this was supposed to be its origin in those days. The authorities then consulted Chr. Hunäus (1803-1882), professor of geology at the Polytechnische Schule of Hanover, who confessed that nothing certain was known about the origin of the petroleum in the Wietze region and recommended drilling to study this problem.

Others had meanwhile attempted this. Stechhahn, a factory-owner, and Hostmann, a Celle banker had drilled for coal on several sites and had even sunk a 130′ shaft, but had to give up on account of the high costs, according to an official notice of December 10, 1853. One of their wells had yielded traces of petroleum (1849).

The records prove clearly that Hunäus knew nothing of Drake's successful well at Titusville (1859) when he was commissioned to sink wells in the Wietze-Hänigsen-Oedesse region and drilled 13 wells in the period 1857-1863.

There were five "tar-wells" (Theerkuhlen) at Wietze, probably in use

[1] H. B. Goodrich, Early discoveries of petroleum in the U.S.A. (Economic Geology vol. XXVII, 1932, pp. 160-168). — K. H. Blumenberg, Die ältesten Erdölsonden (Petroleum vol. XXVIII, 1932, p. 10).

[2] K. H. Blumenberg, Wietze oder Titusville (Petroleumind. Tägl. Ber. vol. XXV, 1931, No. 185, pp. 2-3) (Int. Z. Bohrtechnik, Erdölbergbau u. Geologie, vol. XXXIX, 1931, pp. 134-135). — Die ersten deutschen Erdölbohrungen in Wietze, Hänigsen und Oedesse (Hannover, 1932, mss.).

since 1860, when Taube made his visit. The only two productive ones were those belonging to Wallmann and to the miller Heinrichs. The crude oil produced (specific grav. 0.940-0.955) was a dark, very viscous liquid. The first well was started in the Wallmann pit on the advice of Hunäus and Hahse early April 1858. It was drilled with a 10'' bit and reached a depth of 122 feet (the Hanoverian foot is equal to 29.21 cm.) without success on May 29, 1859. On September 29, 1859 Hunäus was ordered to stop drilling here. In November 1859 the miller Heinrichs asked for the loan of the drilling equipment at this abandoned well to drill on his own site. After some deliberation this well was started in March 1860 and sunk to 110 feet when a small quantity of "tar" was obtained.

The drill met a block of granite at this depth and two attempts to drill further failed. Blumenberg has traced the history of this and other wells in great detail, which enables us to reconstruct these early methods of drilling.

Curiously enough production at Wietze would have been profitable at that time. The increased production of the Wallmann pit attained some 540 pitchers a year, equivalent to 135 "skins" (a "skin" comprising four pitchers was then the unit) which sold at 4 Thaler each. Hence the income of 540 Thaler a year would have easily paid for the cost of drilling which amounted to 460 Thaler only! The oil was still used as a medicine and a lubricant as in the days of Taube but fetched relatively high prices.

At Hänigsen drilling met with strong opposition from the local population which from the days of Agricola had exploited their seepages. Finally a contract was signed and in June 1860 the first well was sunk on a plot belonging to one Haarstrick. On June 23, 1860 a thin crude oil was struck at a depth of 119 feet. On July 4, 1860 the bit struck a hard sandstone stratum which caused many difficulties, including a breakage of the cable on November 28, 1861, when a depth of 191 feet had been reached. The 10'' well had then to be abandoned because it was impossible in those days to recover drilling tools at that depth. At that time the local population still exploited some 75 shallow shafts about 2.0-2.5 m. long, 0.60-1.00 m. wide and upto 5 m. deep.

At Oedesse (Edenissen) five "tar-pools" are shown on a map of 1740, all along a small brook called Blackwater (Schwarzwasser) about one mile north of Peine. Here again the Saltworks Inspector Hahse started drilling near the three most productive seepages. Drilling was begun on May 9, 1862 and slowly reached a depth of 51 feet in July 1862, after which the well was abandoned as the authorities considered that sufficient data were available on deeper strata from the 130′ shaft sunk by Stechhahn and Hostmann.

These three wells were the only relatively successful ones sunk for the very purpose of finding the source of the seepage oil. Only the well drilled

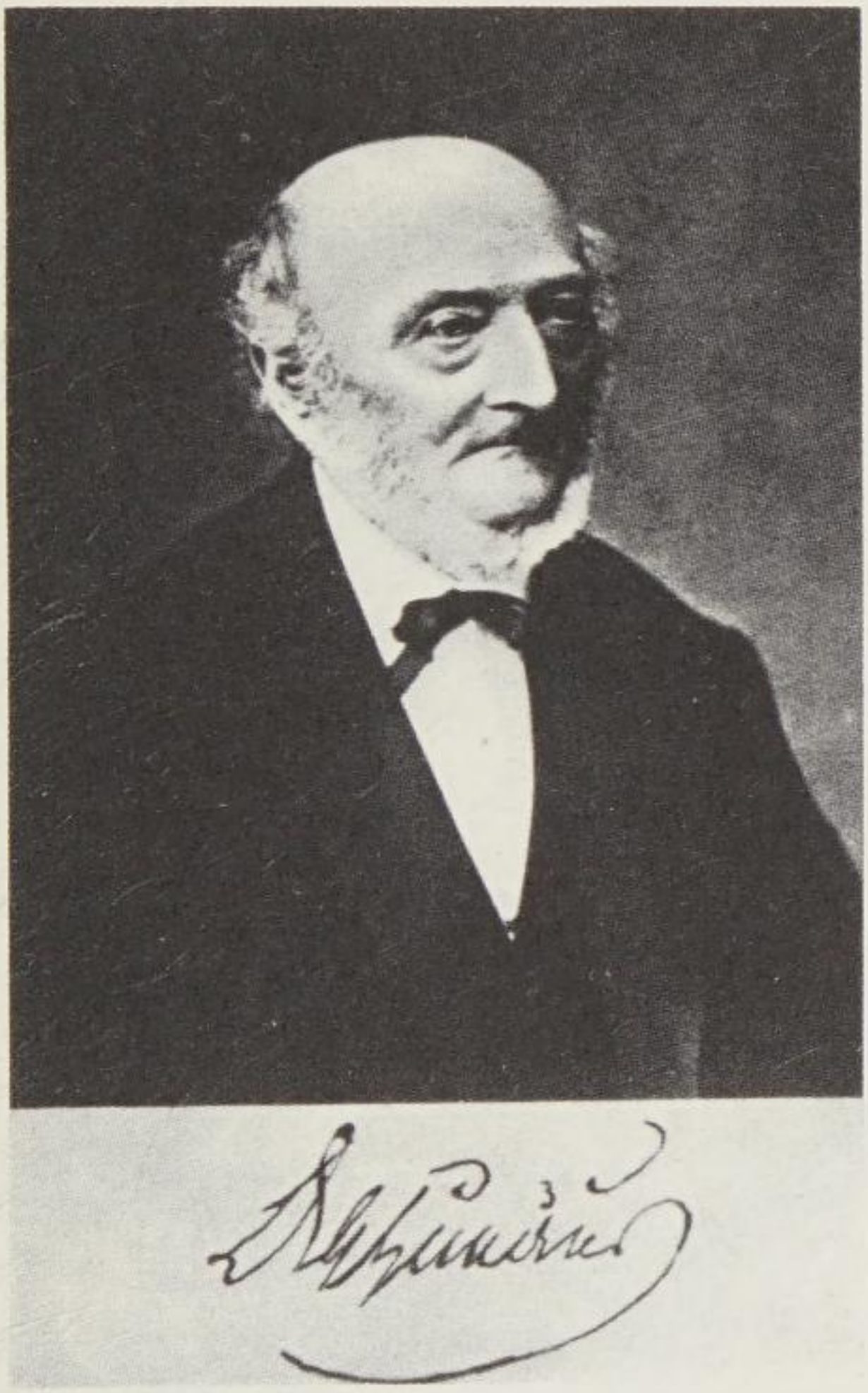
by the miller Heinrichs of Wietze can be said to have been sunk for the purpose of producing oil like that of Drake. Soon after these attempts news of the outstanding successes of oil drillings in the United States reached Germany and drilling for oil in these regions slowly gathered momentum. About 1881 sufficient capital was invested to enable drilling to be started on a large scale, and this led incidentally to the first oil crisis in Europe.

On July 21, 1881 Adolf M. Mohr struck oil at Oelheim near Peine in his third well at a depth of some 69 m. This gusher gave a plentiful supply of oil, contemporary estimates varying from 40 to 75 tons per day. Others soon rushed to Oelheim and started drilling, often not more than 30 feet from the neighbouring derricks. The shares of the "Oelheimer Petroleum-Industrie Gesellschaft Adolf M. Mohr" rose sharply within a few days after the foundation of the company (August 10, 1881), though a warning was given not to expect too much. [1] Speculators organised trips to the oilfields and on one day (August 29, 1881) no less than 250 journalists and other inhabitants of Berlin were shown around at Oelheim and lavishly entertained. The crash came a few months afterwards (November 1881) when shareholders became aware of financial manipulations by directors and of the gradual appearance of water in many of the promising wells.

However, such growing pains were typical of many oil regions and did not impede the gradual development of Oelheim, Wietze and Hänigsen to become important European producers of crude oil in the course of our century. When the asphalt road was invented and introduced during the nineteenth century attention was again given to the exploitation of asphaltic limestones in the Hanover region. Simms gives the following interesting details:

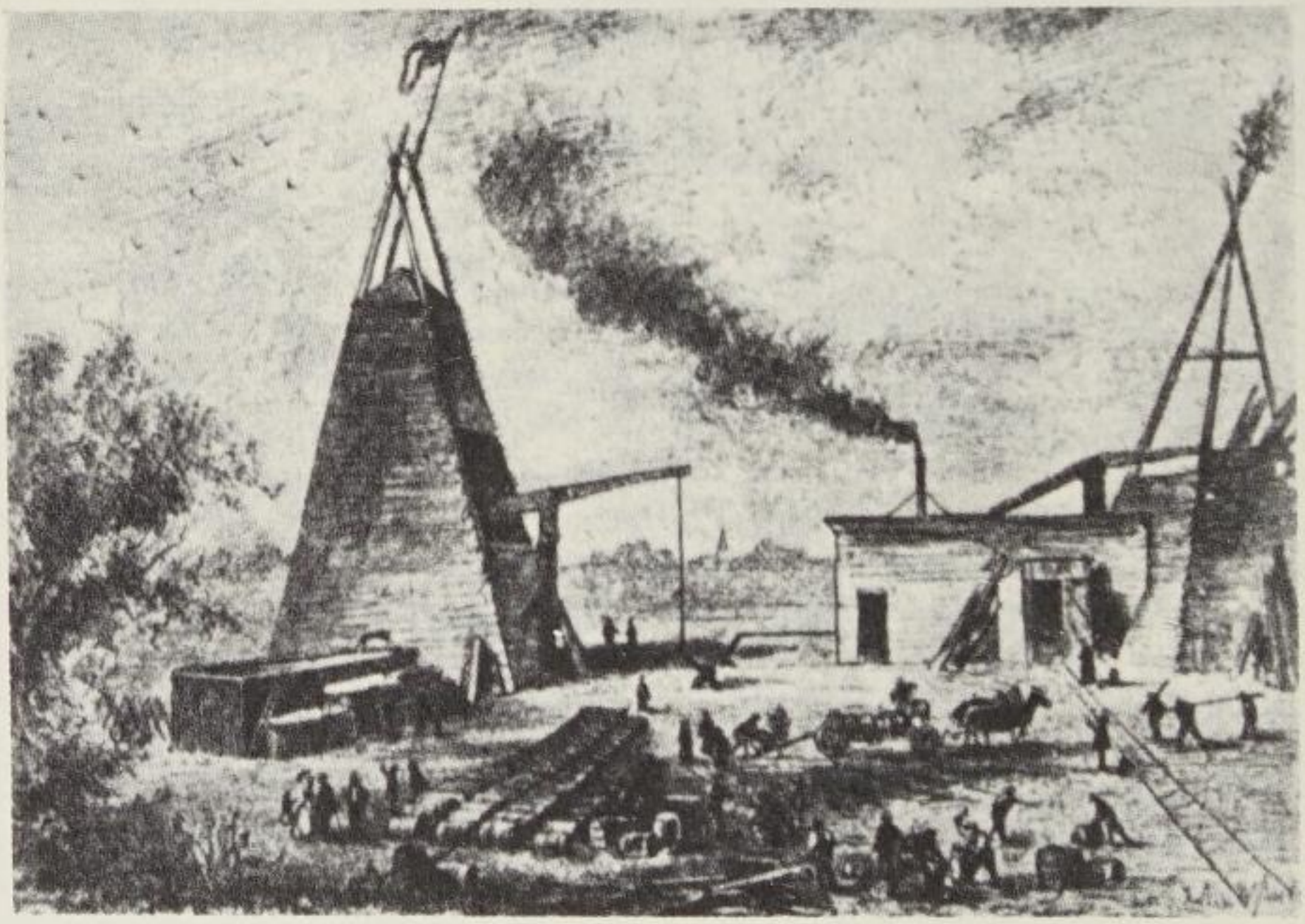
"In the year 1843, a bed of asphalt stone, similar to those of the Val de Travers and of Seyssel, was discovered at Limmer, near the town of Hanover; and Herr Hemming established similar works with such success that the Limmer asphalt was considered worthy to be classed with the above named asphalts; indeed in the first London Exhibition superiority was assigned to the German asphalt over that of the older companies. The broad foot pavements of the streets of the town of Hanover bear witness to its excellence. The fact that the mountains which border the great German plain extending through the district of Hanover are rich in bitumen and mineral tar, was a great advantage to the asphalt works at Limmer. When, however, the granite or tile footpavements, were gradually substituted for the asphalt, as for example in Berlin, it became necessary to seek some other means of employing the asphalt. The solution of the problem was found in paving the streets of large towns, a task requiring unlimited quantities of the material, which the railways now placed within reach. The experiment was tried of laying down broken freestone on a bed of sand and filling up the interstices with molten asphalt mastic. It proved unsuccessful however, for, when cold, the mastic was too brittle for the purpose; and if the

[1] Notice in the Berliner Börsen-Courier of August 12, 1881.



Prof. Dr. Georg Christian Konrad Hunäus (1803-1882), who surveyed drilling in the Wietze region (After Blumenberg).

The old well in the "Teerkuhle" on the Wallman farm near Wietze (Photo Dr. Behme, 1926).



Ad. M. Mohr's well no. 3 near Oelheim (After a contemporary print by Alfred Schütze).

wheels of the carriages struck against and broke one of the corners of the stones, a hole was formed, which gradually widened and was very difficult to mend. In Lyons 10,000 cubic metres of roadway were covered with a layer of asphalt of about 2 in. in depth, upon a substratum of concrete of about 4 in.; and this was found to answer admirably, but was so costly that in other towns the municipalities were obliged to content themselves with covering in that way the places where the most crowded thoroughfares crossed, and the spaces in front of public buildings, where it was important to deaden the noise of the traffic. In these cases it was found desirable to furrow the surface, to prevent accidents to the horses, which were never long enough on the asphalt to get used to the change from the rougher road; but in Lyons, where the asphalt is more general, this precaution has been found unnecessary.

The Limmer asphalt seems particularly suitable for this purpose, being rather softer and more oily than that of Switzerland or Savoy. In the heat of the summer it becomes marked by the impressions of the carriage wheels and for this reason it has always been found necessary to mix with it some of the dryer asphalt of Vorwohle for foot pavements. A solid foundation is first prepared, which is covered with a layer of coarse asphalt 2 in. thick and containing 10 per cent. of tar, and beaten down till it is quite hard; then a layer, 1 in. thick, of asphalt consisting of 75 per cent. of mastic, 3 per cent. tar and 22 per cent. of coarse sand is added. A similar kind of composition was used in Hanover for the flooring of the cavalry stables, the saving in straw, cleanliness, and freedom from smell being found to be a great advantage. The writer was shown roads paved with the Limmer stone, and with the three kinds of asphalt, viz. the compressed asphalt, the asphalt macadam, and the asphalt mastic; of these only the mastic road could be said to be thoroughly successful."

Simms [1] also mentions that bituminous limestone was found at Hölle near Heide (Ditmarschen, Hollstein) north of Hamburg, which Meyn [2] later considered too soft for roadbuilding as it could be cut like cheese. Simms reports this:

"At Hölle near Heide we find a bituminous limestone 1000′ in extent, in which the bitumen is as closely united with the limestone as in the case of the Val de Travers or Seyssel asphalt, but according to the opinion of the Paris Asphalt Company it contains too much pure petroleum for direct application (owing to its position under 120′ of diluvial soil). It is, however, hoped either that by exposure to the air part of the petroleum will be lost, and part so far oxidized as to produce a perfect asphaltstone or that on further investigation some limestone be found containing a larger proportion of tar and less petroleum."

As far as we know it was never exploited until recently.

[1] F. W. Simms, Practical observations on the asphaltic cement or mastic of Seyssel . . . (London, 1837).

[2] Meyn, Der Asfalt und seine Bedeutung für den Strassenbau grosser Städte (Halle, 1872).

CHAPTER FIVE

THE OIL OF ST. QUIRINUS AND THE BLOOD OF THYRSUS (Dirschoel)

On the north-eastern flanks of the Alps two outcrops of oil-bearing strata have acquired fame in the course of the ages because of the medicinal value of the petroleum products produced there rather than for the quantities which up to the present remain negligible. They are Tegernsee (Bavaria) with its Oil of St. Quirinus and Seefeld (Tyrol) with its Blood of Thyrsus. Both have a history which goes back into the Middle Ages and both are deeply rooted in the folk medicine in this region.

1. *The Oil of St. Quirinus*

The old seepages of Tegernsee are situated on the west bank of the lake not far from the village of Wiessee. A little stream called "Breitenbach" enters the lake near the Finner farmstead. Some 15 minutes up the road to the Kobogner farmstead are the seepages. The most important of these are enclosed by the chapel dedicated to St. Quirinus and ooze forth from peat and marl-strata. A stone tablet informs the visitor that they were discovered in 1450 and re-enclosed in 1828. Tradition has it that the seepages were discovered by monks from the rich Benedictine monastery on the east bank of the lake. For centuries the monks sold the crude as "Oil of St. Quirinus" for its real and imagined medicinal virtues. Even after the secularization of the monastery in 1803 Dr. Joseph von Hefner reports that the miraculous oil was sold with a pamphlet describing its virtues and cures by the glazier of Tegernsee at four guilders a "Maass" (a jar). Even nowadays the country folk between Hirschberg and Wendelstein still use it as a medicine and as a lubricant for their carts "as this amounts to the same thing" according to the old landlord of Rottach whom Oertel interviewed on these matters. [1]

Even now many countryfolk still believe that the oil oozes forth from the body of St. Quirinus. Sometimes traces of oil flow down to the sea on the surface of the Breitenbach and form thin streaks on the lake's surface which

[1] F. Oertel, Die Petroleumquelle am Tegernsee (Beil. Allg. Ztg. No. 81, 1907) (Petroleum vol. II, 1907, pp. 613-614).

prevent the formation of waves in times of stormy weather. In winter time droplets of oil and bubbles of gas collect under the ice and produce interesting light reflexes. The boys of the neighbouring farms gather together to "set the ice alight" (Eisanzünden). They cut a hole in the ice and set the oil afire to the delight of the spectators on the shore.

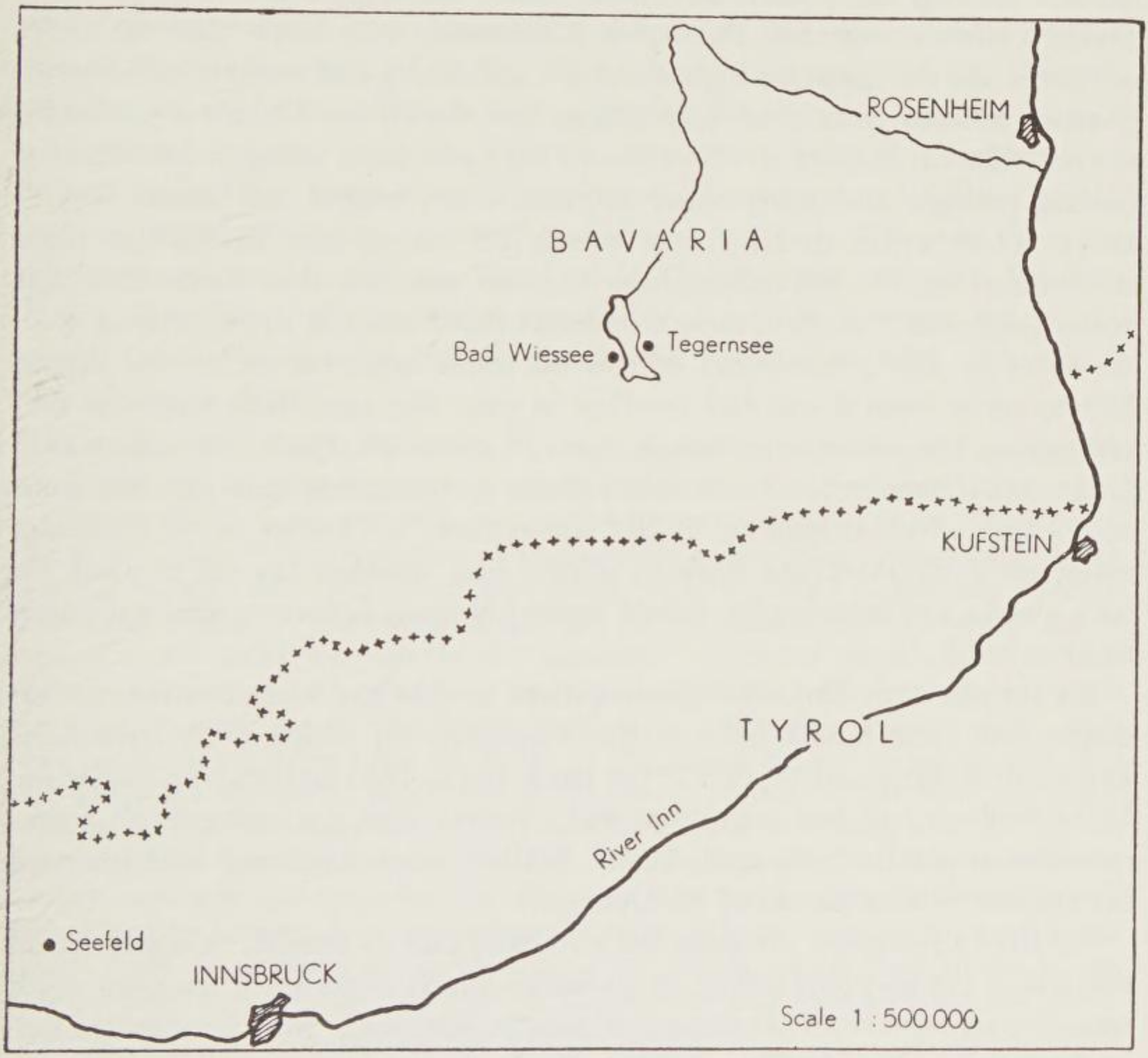


Fig. 11. Map of the Tegernsee-Seefeld region.

There is some doubt about the date when these seepages were discovered. The "Chronicum Tegernseense", covering the period of 1347 to 1445, mentions that "over against the afore-mentioned chapel the brethern discovered a vein of petroleum oil (olei petrolei) which has now been flowing for about forty years. Persons afflicted with palsied and shrivelled limbs smeared with this oil have in many cases been restored to their former health". Taking into

account the date when these chronicles were written this would put the date of discovery back to the years 1440 or 1441.

Beckmann [1] has drawn the attention to the correspondence of Duke William III of Bayern-München, the protector of the Council of Basle since 1413, who in the spring of 1433 married Margaret, daughter of Duke Adolf of Cleves. During the preliminary discussions which preceded this marriage Duke William's secretary, Friederich Aichstetter, who knew that the Duke of Cleves like the Emperor Sigismund of Luxemburg and many other contemporaries suffered from gout or podagra, had drawn the Duke's attention to the fact that "in Bavaria oil flows from a high mountain which is excellent for healing podagra and many other diseases which plague the human body". Duke Adolf writes to his future son-in-law asking him to confirm these contentions of his secretary. Duke William answers that Aichstetter was correct and that "we have seen wonderful cures effected by it". Along with his letter he sent a bottle full of this oil sealed with the secret seal urging him to try it "and if you feel twitches in your feet oint them with this oil" and urging him to believe "that it cures all diseases". Early November 1433 Duke Adolf thanks his son-in-law for the gift assuring him that the gout or podagra which attacks his limbs "comes from hot matter as my physician maintains". Would Duke William inform him whether the oil is good for such attacks and whether he should smear his limbs before or after they start to hurt him?

We do not have Duke William's answer to this last letter but there is no doubt that these letters refer to the Tegernsee oil which must have been known in Bavaria and beyond at the latest about 1430 and may be earlier for Duke William had had many personal contacts with the monastery's representative at the Basle Council, Ulrich Stöckel, who must have told him and his secretary about the oil of St. Quirinus.

We have a pamphlet extolling the virtues of this oil entitled "Origin, action and use of the so-called Oil of St. Quirinus which oozes forth from the earth near the monastery of Tegernsee in Upper Bavaria", which pamphlet will be discussed in detail in Chapter VIII. We are there informed that the discovery took place during the reign of the holy abbot Kaspar in 1430. This Abbot Kaspar was raised to his seat at the age of 24 in 1426 and his wisdom did much to restore the wealth and influence of this rich monastery which had come down by mismanagement and staggered under the load of debts. The young abbot had the partially ruined buildings of the monastery restored by skilled lay brethern led by a stone-mason Hanns of Münich. He also had a stone

[1] G. Beckmann, Die Petroleumquellen am Tegernsee (Beil. Allg. Ztg. No. 83, München, 1907).

chapel built for St. Quirinus instead of the older wooden one, restored the large well in the market of Holzkirchen and did everything to raise the prestige of his monastery. This demanded much money, most of which was derived from the sale of the oil of St. Quirinus promoted by the broadsheet mentioned above. The yearly production was some 500 Maass (jars) in the early days.

Nöldecke [1] estimates that some 42 L. of crude have been produced daily since the discovery of the Tegernsee seepage, but this figure seems high in view of the results obtained in this region during the last century. There is, however, no doubt that its fame spread during the sixteenth century when it is mentioned in many sources. Agricola mentions it [2] and it is indicated on the map of Bavaria designed by Philip Apian (Bienewitz) in 1568 and on the map of Tegernsee drawn by Matthew Merian in 1644. We hear from an eighteenth-century source how this oil of St. Quirinus was collected. Matthias Flurl, an important official (Geheimrat and Vorstand der General-Bergwerks Salinen- und Münzadministrator) visited the seepage in 1792 and this is what he has to say [3]:

"But what above all must arouse the curiosity of the travelling naturalist here near Tegernsee is seeing the place of origin of a fossil which has attracted attention in these parts for some centuries past, and which was distributed to the common man in the times of our forefathers as a miraculous sacred thing. I mean the so-called Quirinus oil, with the origin and effect of which I wish to make you perfectly familiar. Sacred and venerable you remain always for us, wonderful Mother Nature, and in precipices and rocks we perceive the miraculous power of the Master who bids boiling-hot springs and refreshing health-waters burst forth from deep gorges and who has made the oil that brings health to you also well up from them. Such were my thoughts when I left the shore by the monastery and sailed towards that part where the honour of being shown the source of this oil was done me. I got someone to tell me beforehand that it is sometimes seen flowing into the lake in fine streaks and lines and this narrative I found to be not entirely lacking foundation; for one need only put one's hand in the water when in the neighbourhood where the oil-bearing springs flow down into the lake, and one finds on drawing it out usually a few small drops of oil sticking to the fingers, which must be the reason why the lake, especially in dull weather, appears covered with blotches and spots.

No sooner has one covered about half the length of the lake when, between the mountains of sandstone alternating with limestone layers of different thickness that advance towards the lake on the western shores, a little gorge opens, down the middle of which dashes a little stream in a ravine. If one climbs up its watercourse for some distance, one notices on all sides a penetrating bituminous smell which comes from the frequently-occurring oil-bearing springs welling up at the side . . .

[1] Nöldecke, Vorkommen und Ursprung des Petroleums (Berlin 1883).
[2] G. Agricola, De Ortu et causis subterranorium (Basel, 1546).
[3] Matthias Flurl, Beschreibung der Gebirge von Baiern und der obern Pfalz (München, 1792).

The two main springs, however, burst forth above on the ridge of this not very high mountain below the face of rock found there lying on top of the sandstone; and one of them is led by the monastery to marsh land in a wooden conduit while the other by means of a hewn-out canal is led into a so-called Quirinus chapel, erected from stones, and kept in better preservation. However fluid this oil may be under the earth, so that it can be swept away by the water and carried out with it, it nevertheless congeals immediately above ground and appears as a slippery paste of olive-green colour. The latter is often skimmed off with copper spoons and reduced to a completely liquid state over a low fire, filled thus into little glass bottles and given away by the local monks to their vassals and admirers. In this state it is scarcely translucent, but completely opaque and brown, and always retains a penetrating, not wholly unpleasant smell. Often it takes on a yellowish-brown colour and always congeals below its natural temperature. It has this in common with pure mountain oil or naphtha, that at least at the spot where it occurs in accumulation it catches fire even from a distance. The monastery did not discover that until a few years ago and as a result set fire to one of its huts, where the Quirinus chapel built from the materials of the ground described above now stands . . .

But lest I omit to tell you something of the effects of this wonderful oil, it serves not merely externally for callosities and obstructions; but is pre-eminently a very popular remedy for earache; and the peasants settled in the neighbourhood, who collect it in their own ditches partly for burning and partly for mixing it with their greases for their carts, fetch it straight from the spring. Nowadays there is scarcely a single priest in the monastery who does not take it for anything other than natural rock oil. The quantity of the oil collected in the two huts is said to amount to 30 to 40 jars per annum, not counting that which the peasants catch in their ditches and which will be not much less. To expedite this collection still further a little tunnel dug into the oil-bearing rock with several side-branches would give the best service; for to me it seems that not only here but also in the entire neighbourhood everything is saturated with mineral oil, indeed you came across it frequently in the cavities and caverns of the marble quarries two hours' journey distant."

Similar reports come from such contemporary authors as Franz von Paula Schrank (1793) and Joseph von Obernberg (1815). The first, visiting Tegernsee in 1788 thinks that "agriculture, horticulture, etc. would profit if mining were started and the oil would be produced in larger quantities". This happened a generation later.

When in 1803 the monastery of Tegernsee was secularized the Bavarian State, now owner of the Finner and Rohbogen farms and their seepages, tried to boost their production from 1838 onwards by digging handshafts and a few horizontal galleries, but the latter attempt had to be given up by 1840 because the gases evolved seriously endangered the miner's health. The oil was still skimmed from the water oozing forth from the oil-bearing strata and it was still traditionally sold as a lubricant for waggons and a medicine for cattle. In this way upto 2600 jars of oil were produced yearly during the period of 1839-1873.

In the year 1881 two Münich banking-houses tried their luck and sank wells on the Finner and Rohbogen farms. [1] Nine wells were sunk but in January 1887 only one of these had produced a total of 200 tons and the others were dry wells. Then the Chemische Fabrik A.G. of Hamburg took over the licenses and produced another 127 tons upto 1900 though further wells sunk in this region were again a disappointment. The Flysch zone of strata was believed to be the source of the petroleum produced, its rocks had many fossil fish which were thought to be the matrix from which the petroleum had been formed in the course of ages. Similar theories were developed about the origin of the Seefeld oil in nearby Tyrol and for many decennia such theories were debated by geologists like Gümbel, Fink and others. [2] The geology of the region proved extremely complex.

In 1903 the Dordtsche Petroleum Maatschappij took an interest in this petroleum. Its director A. Stoop sent A. Driessen to Tegernsee to head a mission searching for oil. In 1907 the Erste Bayerische Petroleum Gesellschaft m.b.H. was founded but though 11 wells were sunk between 1904 and 1912 no great success was obtained. When the amalgamation of the Dordtsche and the Royal Dutch took place the latter had no further interest in this exploration [3] and stopped the work in 1912. During the First World War the authorities obtained some production from the few successful wells, but from August 15, 1906 upto December 31, 1919 no more than a total of 4148 tons of oil have been produced here.

The early explorers in this region had been rather enthusiastic of the quality of the Tegernsee oil. The "olivegreen oil with its aromatic resinous smell" was analysed by Dr. Graf (1803), Prof. Buchner (1819) and Prof. F. von Kobell (1883). The following table, taken from an early work on the types of crude oils in Germany [4] tended to show (according to the authors of this book) that this crude was even better than Pennsylvanian crude, the standard of that period (see table page 64).

A contemporary writer, Kollmann expressed the opinion that "the crude of Tegernsee has all the advantages of a high naphtha (gasoline) and paraffin (kerosine)-content which makes it equal to and even better than Pennsylvanian crude. It would seem that by improved methods of distillation more than

[1] B. Förster & K. Oebbeke, Tiefbohrungen am Tegernsee (Geognostische Jahreshefte vol. XXXV, 1922, pp. 83-159).

[2] H. de Terra, Die Erdölbohrung Holz am Tegernsee (Geognostische Jahreshefte vol. XL, 1927, pp. 7-22). — G. Herbst & R. Teichmüller, Die Erdöllagerstätte am Tegernsee (Oberbayern) (Kali, vol. XXX, 1936, pp. 1-5, 11-15).

[3] A. Driessen, Bad Wiessee am Tegernsee (München, 1920).

[4] Kraemer & Böttcher, Über die deutschen Rohpetrole, deren Untersuchung und Verarbeitung (Verh. Ver. z. Beförderung des Gewerbefleisses 1886/87, Berlin).

	up to 150° Petrol		up to 250° Kerosine		up to 300° Solar oil		over 300° Paraffin-oil, Lubricating oil and steam		Residue	
	%	sp.gr.	%	sp.gr.	%	sp.gr.	%	sp.gr.	%	sp.gr.
Tegernsee	20.04	0.812	26.12	0.726	14.02	0.782	35.91	0.825	3.07	0.856
Pechelbronn	1.30	0.888	16.37	0.720	17.07	0.778	47.88	0.824	16.28	0.893
Oelheim	0.74	0.885	11.05	0.750	9.75	0.805	73.91	0.852	3.92	0.900
Pennsylvania	14.34	0.814	25.35	0.725	13.75	0.811	40.99	0.820	5.57	0.850
Western Galicia	14.21	0.842	16.93	0.723	12.30	0.786	47.58	0.830	8.95	0.882
Baku	0.63	0.880	21.73	0.762	15.55	0.811	57.97	0.853	4.10	0.903

39% of kerosine could be produced from this crude." Unfortunately the dreams of a Bavarian Oil Creek faded away and this field never developed into a main European producer.

2. *The Blood of Thyrsus*

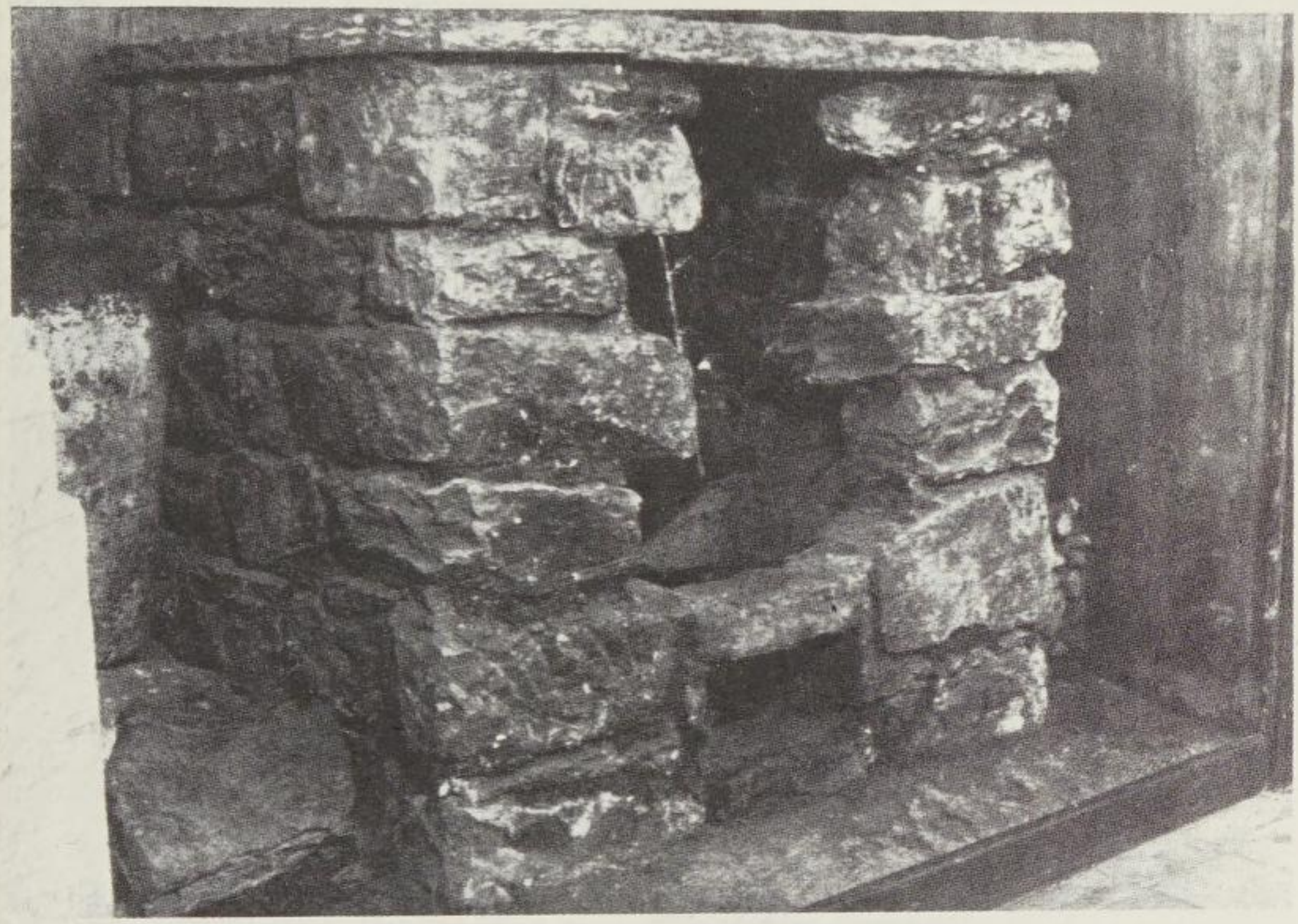
There is no doubt that the outcrops of oilshales and bituminous rocks have been known in Tyrol for many centuries. [1] At Seefeld are found two types of bituminous marl, the "black stone" and the "red stone" (Dirschenite), the first of which contains an oil with 10% of sulphur, the latter an oil of seldom less than 12%. The oil recovered has a large percentage of thiophenic compounds, because of the many fossil fish found in the bituminous strata, some of the products are called "ichtyol". The fact that two types of bituminous rock were available near Seefeld made it possible to produce products with a constant sulphur content. Further oilshales are of Jurassic (Achensee), Cretaceous (southern Tyrol) and even Diluvial (Lower Inn valley) date. The bituminous strata vary much in thickness and as the geological structure is most complicated and many folds occur, mining is fairly expensive and the galleries driven into the mountain-side to tap the bituminous strata demand much labour. About one-tenth of the bituminous rock mined is worth further treatment. The huge heaps near the mouth of the shafts and galleries consist of the useless gangue separated from the richer shale and used for road construction and the like only. The rich shale shows a dull conchoidal fracture, the colour varies from light grey to yellow, brown and black. On heating it gives off sulphurous vapours and sometimes burns easily.

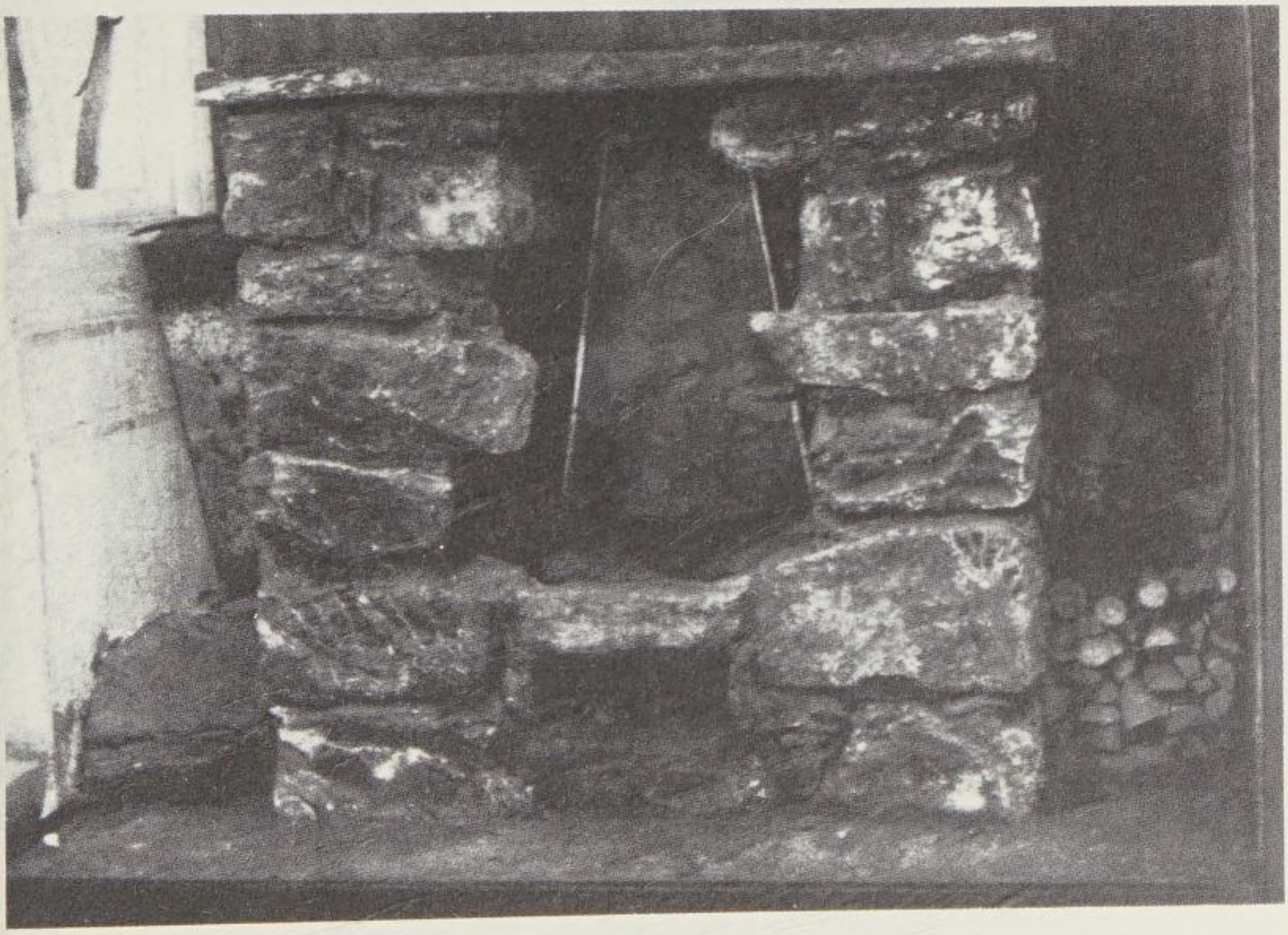
The local legend claims that the oil produced from this rock is really the

[1] L. Kroeber, Der Seefelder Oelschiefer (Süddeutsche Apoth. Ztg. vol. 71, 1931, No. 37, pp. 257-259). — G. Hradil & H. von Falzer, Die Oelschiefer Tirols (Barth, Leipzig, 1930)

Map of the Tegernsee by Matthew Merian (1644). (Photo Bayerische. Staatsbibliothek Munich). The central bay on the west-side of the lake is marked "Oelwinkel" (oil-corner) and the central detail picture on the right side of the map shows a small map of the "world-famous oil-brook full of grace and healing" as well as a view of the chapel of St. Quirinus.

The battle between Thyrsus and Haymon as depicted in a wall-painting on a house at Leithen near Reith.





Model of the furnace used for the production of kerosene from Seefeld oilshale (Photos no 6766 and 6767 of the Vienna Techn. Museum).

Statue of the giant Thyrsus in the facade of the abbey church of Wilten.

blood of a giant called Thyrsus. [1] When Theodoric of Bern (about 500 A.D.) marched from Italy to the north on the old Roman road he was accompanied by a giant called Haymon who freed the peasants of the Inn valley from the incursions of a dragon which he slew. He was then asked to stay and govern the country instead of going home to the Rhineland. This brought him into conflict with another giant called Thyrsus already living in the valley. A duel took place on the banks of the stream near the present village of Leithen. Haymon wounded Thyrsus mortally though armed only with a treetrunk. As Thyrsus fled into the rocks he called upon the blood ebbing from his body "go, blameless blood and help beasts and mankind". Haymon regretted his act and built on the site of the ancient Roman settlement of Veldidena a monastery called Wilten. He retired into the mountains of Seefeld where he lived as a hermit. One day when cooking his meal he perceived drops oozing forth from the stones of the hearth, which drops he held to be the congealed blood of the slain Thyrsus. He also discovered that this "Blood of Thyrsus" cured many diseases of beast and man. Soon the population flocked to his hermitage to obtain this wondrous oil and thus the art of producing it became known. [2]

The oil is called locally Thyrsenblut, Tyrschen- or Dirschen-öl, Dürsten- or Dirstenöl. A hamlet near Zirl is called Dirschenbach, the mountain above the village of Leithen is called the Dirschenkopf. The earliest reference to this oil occurs in a document of 1350 which gives the knight Berthold von Ebenhausen the Just the right of "burning the oil" by the decision of the court of justice of Heartenberg near Telfs in the Upper Inn valley. This gives us grounds for believing that the process of extracting the oil from this local shale was well-known by 1300. Thirty years later Ebenhausen Ulrich von Matsch obtained a similar privilege. When the Archduke Ferdinand of Habsburg confers on Abraham Schnitzer the sole right of producing this oil for twenty years in 1576 this is "because with the grace of God and by his diligence he has discovered a special art of producing from certain stones which are to be found here and there in the county of Tyrol and which are called "Tyrstenblut" a most precious oil." [3] He was, therefore, not the inventor of the process of extraction, but he improved a more primitive one.

The method for extracting the oil from the bituminous rock was that of "destillatio per descensum". Details can be gleaned from a water-tint by

[1] Fr. Sedlacek, Thyrsenblut (Blätter Gesch. Technik, Heft I, Wien 1932, pp. 73-80).
[2] L. Winkler, Thyrsenblut und Thyrsenöl (Pharm. Monatshefte vol. IV, 1923, pp. 105-106).
[3] P. Justinian Ladurnes, Historisch technische Notizen der Provinz Tirol 1812 (Arch. f. Gesch. Altert. kunde Tirols vol. II, 1865, p. 375).

M. Burgklehner now in the Ferdinandeum. A hearth-like stone sub-structure bore six to nine distillation-vessels. Stoneware flasks from Obernzell or Passau were used for this purpose. They were filled with bits of "stinking stone" and closed by a perforated iron plate luted with loam and installed upside down on the hearth in such a way that each still gave into a funnel projecting from the hearth and ending in a wooden pipe which ended in a collective outflow pipe. The fire-wood was then assembled around the stills and fired from the top downwards. Thus the vapours formed by distillation and cracking were driven downwards into the funnel and outflow before further secondary cracking could take place. This process must have been applied in principle

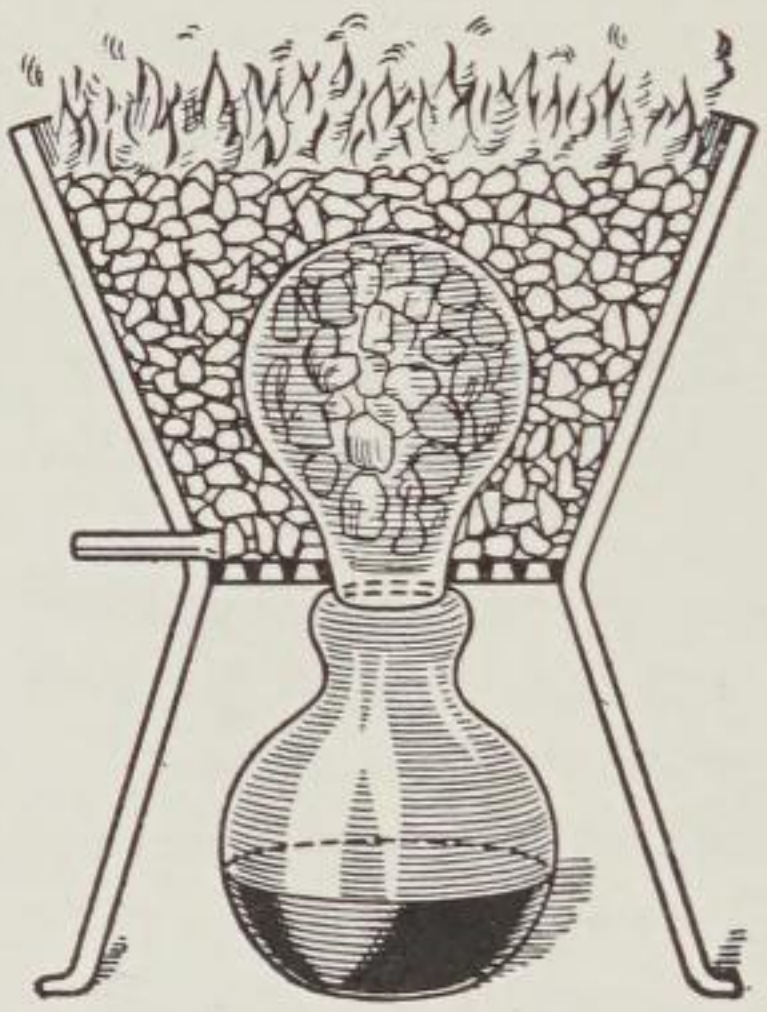


Fig. 12. The principle of "destillatio per descensum".

long before Schnitzer improved it in 1576. The oil produced by this six-hours non-continuous process was then sold by the "Dirscheler", who was the pedlar selling the oil to the peasants in this region and beyond.

Not until 1860 were cast-iron cylindrical stills introduced in this process in imitation of those used by the new bitumen factories, which worked in this region from 1845 to 1860. Staffler reports that this local industry used large quantities of "Stinkstein" from the Hermeleskopf and the Luchsfellkopf. The distillers came from the villages of Reuth, Seefeld and Scharnitz. They produced some 15,000 kgr. of oil per year. From 45,200 kgr. of oilshale some 6,000 kgr. of oil were obtained, which was mostly used for veterinary purposes. An old broadsheet gives details as to its merits and virtues:

"Strength / virtue and effect of the true / attested and unadulterated Blood of Thyrsus / or Rock Oil / which is found at the Seefeld / on the Härmel Joch mountain / in the princely county of Tyrol.

First / this oil is good for people to use for all poison / in time of plague / and whenever the Magyar Disease prevails / taken in broth / and simmered with it. Also anybody who has lice on his body / can banish it / by applying / this oil. And for rank growths on the head / take equal parts of vinegar and rock-oil / mixed together / and by rubbing the temple with it / it will get better. As also for toothache / one or two drops on a piece of cotton / are placed over the tooth / and it gets better. Item / it quells heart-burn and is good / for all growths.

Further: it is good for cattle used for all poison / also for mice / adders and weasels, / to drive them out of the byre. Also if a cow is scratched or bitten / puffed up or swollen / out in the oil simmered to a fair heat / and it will get better. Similarly it can be rubbed onto the sleek parts / and no vermin will come for a long time. Also if a horse has a swelling / or any other injury of long standing / it will be cured with this oil rubbed in. Item / if the cows pass discoloured or bloody urine / 40 or 50 drops of this oil given / will make them well: and if the cattle jump on each other's backs / such oil rubbed on the back / will make them better."

The oilshale of Seefeld was believed to be the "gagates" described by so many classical authors. [1] According to later pharmacopoeia this gagates distilled in retorts produced a "spiritus" (the volatile gases), a "sal volatile" and an "oleum stillatium". Matthiolus, physician to the emperor Ferdinand, wrote [2]: "the gagates is found in the county of Tyrol not far from Innsbruck (Oeniponte) in the beds of certain rivers. This stone was first shown to me by Joh. Petr. Merenda of Brixen, a famous doctor whom the earlier history of gagates was unknown. If fired it contracts and smells after bitumen. Furthermore it is dirty, black, scaly and very light. It is also found in Flanders, Cimbria and Italy." For its application Matthiolus refers to the earlier recipes of Mesue, the Arab physician.

This primitive production of oil from the Seefeld oilshale lasted until 1845 when two firms were founded. The Archiduke Maximilian of Austria was able to combine the licenses of several outcrops and founded the so-called "Maximilianshütte" which produced asphaltic bitumen from the shale which was widely used as a mastic and cement for military constructions such as the "Maximilian towers" of Linz, but also for road-building. Meyn reports in 1873 that "the large Aspern bridge at Vienna had been covered with a double layer of asphalt mastic from Seefeld, the lower stratum being more elastic, the upper somewhat harder. It has not been considered necessary to furrow the surface, and there has not been any increase in accidents to horses in consequence." Foetterle reports [3] on the processes applied in the Maxi-

[1] Pliny, Nat. Hist. XXXVI. 19; Dioscorides V. 103; Galen, De Simpl. lib. 9; Aelius, de re medica II. cap. 24 and others.

[2] Matthiolus comentarii Dioscorides, Venetii 1565.

[3] Fr. Foetterle, Asphaltproduktion von Seefeld (Jahrb. K. K. Geol. Reichsanstalt vol. VII, 1856, pp. 197 & 372).

milianshütte. The "asphaltic rock" of Raggenklan was found to contain 7.71% of bitumen, that of Ochsenregerle 7.28%. The oilshale of Seefeld contained 13.0% of bitumen and 87.0% of calciumcarbonate, the "red stone" yielded some 14.3% of oil-distillate, the "black stone" 20%. The oil was found to contain a high percentage of oxygen (8.2%) against 11.06% of hydrogen and 80.73% of carbon (and no sulphur?).

The bituminous rock recovered from the quarries was produced in pieces of the size of a fist and sorted. The selected pieces were then crushed and sieved and placed in cast-iron retorts for distillation. The poorer rock was crushed and used as a filler in road-building. The tar obtained by distillation was re-distilled into an oil-distillate and a tar, which was mixed with petroleum to a given consistency, and then cast into cakes of standard weight to be sold as mastic.

From 1845 to 1854 about 1.325 tons of rich bituminous stone were produced, 617 tons of poorer stone was sold. The richer stone yielded 262.3 tons of crude "tar", 15.3 of distillate and 247 of "road-tar". The selected rich stone was sold at 1 fl. 30 kr. per hundredweight (of 50 kgr.), the poorer kind at $3\frac{1}{4}$ kr., the tar at 5 fl. 26 kr. and the mastic at 2 fl. 22 kr. Another byproduct of the quarries was a good quality peat which sold readily.

The second firm was the "Erste Tirolische Asphaltgewerkschaft am Gieszenbach bei Seefeld" founded by the merchant Jakob Strasser, which also worked up the bituminous rock to asphaltic bitumen, mixing it with crushed bituminous rock and selling it as mastic. It suffered severely from the competition of the larger firm mentioned above and went into liquidation. However, one of the partners continued the efforts to obtain useful products from the bituminous rock and in 1858 succeeded in manufacturing an excellent kerosine from the Seefeld oilshale (about 12.5 tons in six months). Unfortunately he soon had to end his attempts when kerosine from the new American petroleum industry swamped the European market with a cheaper and better product. With the coming of the modern petroleum industry both firms gave up and local production in the traditional retorts and hearths was again resumed by the peasants. The only change was the adoption of cast-iron retorts in imitation of the more modern factories which we have just discussed. The ashes of the timber used as fuel were collected to be sold as a fertilizer, the burnt marl (with or without some added lime) as a reasonably good cement.

Asphaltic bitumen and mastic were of course no longer produced, the peasants made the old "Dirschöl". Then the Dirschler was again seen on the roads of Tyrol with his high basket (Kraxe) on his back trading the oil to Italy and Germany as a medicine for cattle. Mixed with eggs it gave an excellent lubricant for carts and it was also used against mice.

In 1884 a new phase began at Seefeld. The German dermatologist P. G. Unna had discovered the virtues of "ichtyol" in 1882 [1] and introduced it into the pharmacopoeia. The Ichtyol-Gesellschaft Cordes, Hermanni & Co. was founded at Hamburg, which acquired the rights of the two older firms at Seefeld. The petroleum obtained from the bituminous rock was turned into a water-soluble "ichtyolsulphonic acid" by sulphonization with strong sulphuric acid. This could be turned into "ichtyol" or "Ammonium-sulfo-ichtyolicum". Soon it turned out that the hypothetical ichtyolsulphonic acid did not exist, but that this was a mixture of thiophenes, thio-sulphonic acids and other substances. However, this had no effect on the excellent dermatological properties of the products made and a new outlet was found for the Seefeld production. New quarries were opened and regular production of "ichtyol" was started. Side by side with this modern process the old distillation process in cast-iron retorts was still continuing locally and it survived until well into the twentieth century.

[1] E. Trapp, Das Dürschenblut, Tiroler Oelschiefer und seine Bedeutung (Universum, vol. II, 1947/48, pp. 74-75).

CHAPTER SIX

OIL FROM THE ALSACE REGION (PECHELBRONN AND LOBSANN)

Seepages and outcrops of bituminous rocks on the western bank of the Rhine have been known for many centuries. A group of minor importance is found near Hirzbach an der Ill and Hirsingen in the Ill valley near Altkirch and the Swiss border. A few scattered seepages are found in St. Croix aux Mines, in the Echery hills, St. Hippolyte, Rodern, Mützig and Molsheim, i.e. in the region between the southern and the northern petroleum basins. The petroleum region of northern Alsace, the centre of which is Hagenau, is of major importance. It is one of the modern oil-producing regions of Europe, but its history dates back to the Middle Ages. [1] Here we find seepages and outcrops of rockasphalt at Schwabweiler, Gunstedt, Preuschdorf, Ober-Kutzenhausen, Pechelbronn, Sulz unterm Walde, Lobsann, Lampertsloch, Siebenbrunnenmühle and Walkmühle, Birlenbach, Drachenbrunn and Lochmühle near Kleeberg, of which Pechelbronn and Lobsann are important in petroleum history.

1. *Pechelbronn*

As early as 1498 Whimpheling mentions the local use of oil from Pechelbronn, and Agricola [2] tells us that "there are seepages in many places on earth. In Germany we find them . . . and also near Görsdorff, Alsace." Görsdorff, mentioned as early as 695 A.D. as "Villa Gerleihes" and later (713) as "Gaerlaigovilla" is a small settlement on the road from Wörth to Pechelbronn, where sulphuric acid has been produced by dry distillation of natural alums since 1603. The seepages of Lampertsloch are mentioned in the "Elsasser Chronik" by B. Herzog (1592) and by his contemporary Dr. Helisaeus Rösslin, a local physician who wrote a "Tractate supra allegate".

[1] H. Ludewig, Elsassische Petroleumquellen im 17. Jahrhundert (Nationalzeitung 12. Jan. 1882).

[2] G. Agricola, De natura rerum quae effluent ex terra (1545) (Opera 1657, pp. 535, 538).

The first more detailed description of these Alsace seepages dates back to the early seventeenth century.

In 1625 a 36-page pamphlet (format 10 × 15 cm) was published at the Strasbourg printing press of Jezua Rihel. The pamphlet had been written by Johan Volck and bore the title [1]:

"Description of the Hanau earth balsam, petroleum and soft agate stone, which are found in the village named Lampertsloch, belonging to the most nobly born count Johan Reinhard, Count of Hanau and Zweibrücken etc., etc., together with its qualities, power and efficacy, which various authors ascribe to it, but carefully prepared, tested and found suitable for many purposes: published for the use and the good of all by Johan Volck, servant of the Count of Hanau."

In accordance with the custom of the time Volck (or Volcken) begins his pamphlet with a long preface extending to five pages. In it he points out to his master that he does not intend to speak of the precious balsam from the Psalms of David, or of the oil which dripped from Aaron's head into his beard or of other rare matters, but of the petroleum from the seepage at Lampertsloch close by Zweibrücken, which would in his opinion be paid for in gold even in India. The value of this petroleum cannot be estimated, however, until it has been carefully processed. He thus announces that he will set down his findings, with which at the same time he hopes to prove that in the six years spent in the service of the count of Hanau he has clearly perceived what treasures there are to be won in his territory.

He then points out how the Creator had richly blessed the Count's land with precious gifts such as health-giving springs, which had already been described by Leonhardt Thurneisser, whom he highly revered, but that the petroleum well at Lampertsloch had rarely been discussed, though he himself had discovered that provided this petroleum is carefully treated and distilled, an extremely health-giving substance is to be made from it.

Volck's teacher, Leonhardt Thurneisser zum Thurn, was an alchemist and one of the first followers of Paracelsus, who wished to make chemistry the hand-maiden of medicine.

Thurneisser wrote a "Quinta Essentia" (1574) and a number of other books, which as well as the obvious influence of Paracelsus also bear witness to a strongly independent mind in their author. These early experiments in "applied chemistry" are hardly to be enjoyed by us any longer, mixed as they are with an alchemy tending towards occultism.

From Thurneisser's book Volck quotes "concerning the cold and hot minerals and metal-bearing waters" in order to show that he had by no means

[1] Johann Volck, Hanauischen Erdbalsams, Petrolei oder weichen Agatsteins Beschreibung . . . (Straszburg, J. Rihel, 1625).

discovered the seepage near Lampertsloch, but that it had already been known for a long time. Thurneisser also writes that there is an old shaft or pit near Gerssbach, from which a dirty grease wells up which—because of its more valuable properties—is used by the local population instead of the mixture of resin, tallow and oil for lubricating their carts.

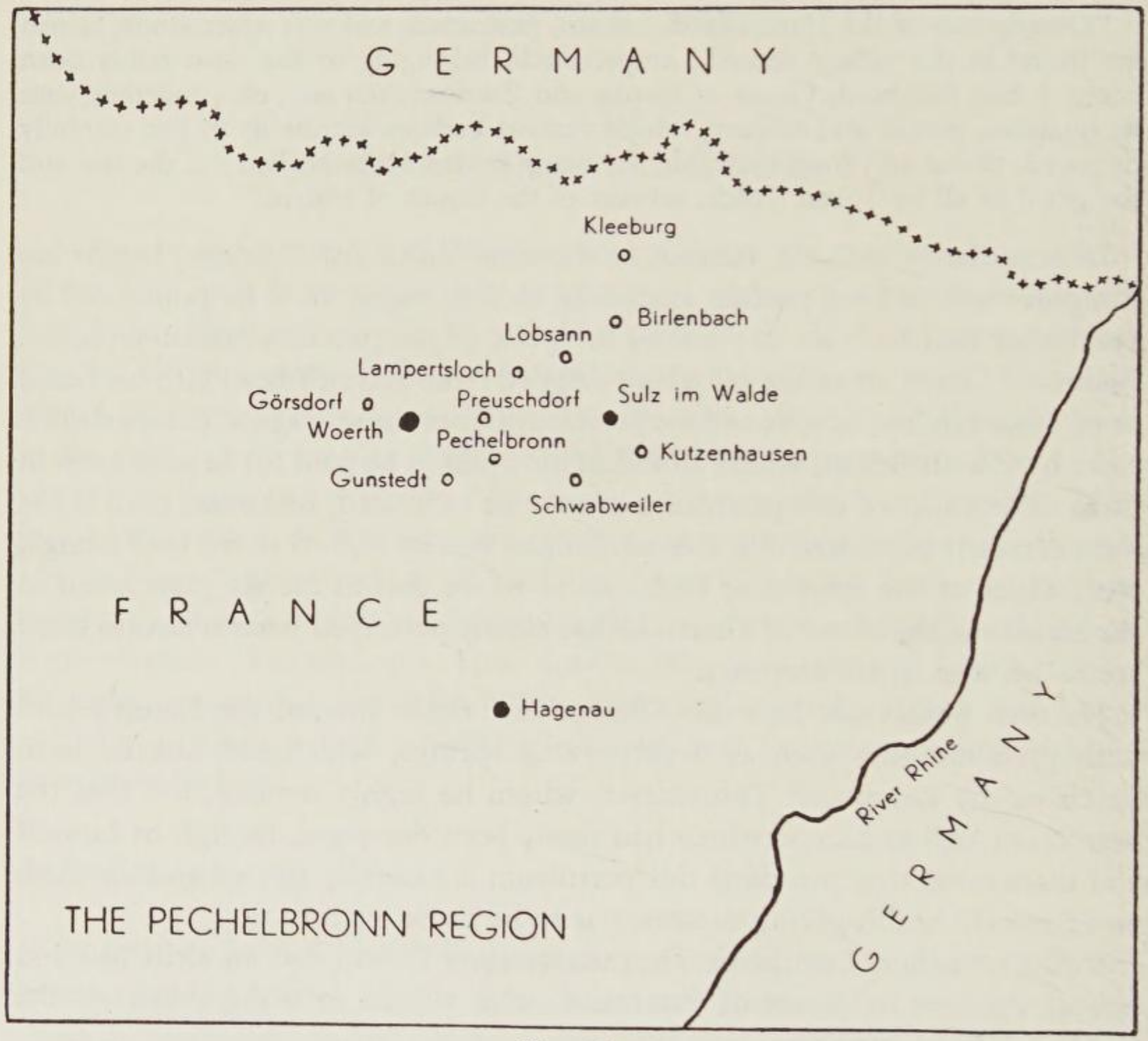


Fig. 13.

If ten litres of this petroleum are heated for three hours over a small fire in a 30 litre pot and care is taken, that no vapour can escape, "almost a quarter of this grease is consumed and an earthy substance resembling ship's pitch is formed as a precipitate on the bottom. An oil floats on top, however, as thin as linseed oil and somewhat yellowish in colour, which can easily be distilled off from the earthy parts, which are of little use". By distillation the oil can be separated into useful parts and residue; for this purpose it should be put into a glass retort with head. If heated carefully on a sand bath, an

aqueous bottom layer (phlegma) is separated from the oil, which floats at the top and which "is nothing but soul and spirit" and above all consists "of the elements fire and air" and which is separated off into the recipient.

Hanawischen Erdbalsams
Petrolei oder weichen Agsteins
Beschreibung:
Welcher bey deß
Hochwolgebornen Grafen
vnd Herren / Herren Johan Rein-
harden Grafen zu Hanaw vnd Zweybrü-
cken/:c. Dorff/ Lampertsloch gelandt/
gefunden wird/
Sampt seiner tugend / krafft
vnd würckung/ die jhme vnderschied-
liche Autores hierinnen begriffen / zueignen/
aber vielfältig præparirt, probirt vnd in man-
cherley gebrechen gut befunden:
Jedermänniglich zu nutz vnd gu-
tem an Tag geben worden/
Durch
Johan Volcken Gräff. Hanaw. Liech-
tenbergischen Dienern.
Straßburg/
In Josi Rihels Sel. Truckerey.
Anno M. DC. XXV.

Fig. 14. Titlepage of Volck's essay on the Lampertsloch oil (1625).

The "phlegma" which remains behind, however, is an excellent remedy for all kinds of lung and liver disorders and should therefore not be thrown away.

Volck then relates how Thurneisser prescribes this oil for the cure of a number of illnesses, just as did Bernhard Hertzog in his "Elsasser Chronick

(1618), from which he also quotes an extract and in which the valuable qualities of the seeping oil, and the subsequently precipitated asphalt are described. Extracts of similar import from the "Tractatu supra allegate" of Helisaeus Roesslin are also reproduced. Roesslin was a doctor at Zabern (Alsace).

Volck then relates how the Count of Hanau commissioned the doctors Max Seibelin, Johan Kieffer, Isaac Habrecht and Antonie Frey to verify the assertions in the older text-books, and how they were in fact able to confirm them. Not satisfied with that, Volck then examined the petroleum and the nearby oil source rocks himself and likewise succeeded in extracting from the latter by (destructive) distillation a fine light yellow oil. He then comes to the conclusion that this distillate possesses preserving qualities and protects against the putrefaction and decay of living flesh, that it is an antidote to poisons, helps against throat and intestinal illnesses, that it is a purgative (based on personal experience), that by means of its "dissolving and softening" effect it can remove harmful substances from the body, and is even good for toothache and gout, burns and sores and many other diseases and ailments.

If Volck had stopped at this point, he would have done little more than verify the assertions which we already know from the pamphlets of his contemporaries in recommendation of the oil from Modena, Tegernsee and Seefeld. The concession to obtain oil at Miano de Medesano close by Modena dates from as early as 1400. We first hear about an oil production of 42 litres per day at Tegernsee (Bavaria) in 1430.

The interesting aspect of his pamphlet, however, resides in the fact that in the last four pages he expatiates upon technical uses of petroleum which we are reproducing here in full because they were not generally accepted until very much later.

"1. The farmers and country-folk come from miles around in order to skim off this crude oil—for so long as they are allowed to—and to use it instead of cart-grease.
2. It is mixed with all kinds of enamels and paints, which are used on wood and other foundations, because it protects against damage by worms and prevents rotting.
3. Thirdly, wood and other materials which are exposed to the weather and are subject to rotting, are painted with it, so that they are better able to withstand corrosion.
4. Further, it is useful for mixing with tar or ship's paint, so that ships and boats coming into contact with salt water are less rapidly corroded.
5. Ships which have been painted below the water line with a mixture of sulphur, lime and crude oil are in this way protected for years against wood-worm and kept in a usable condition.
6. It has also been found very effective in the dressing of leather and can be used

instead of tallow and grease, since it not only makes the leather very supple, but at the same time gives it a fine colour and gloss.

7. It can also be mixed with all kinds of ointments, plasters and dressings and be effectively used for many ailments and diseases, as a doctor in a certain town has been doing daily for a long time and with the best results.
8. It can also be excellently used for burning (especially if the impurities have been removed from it and the water has been separated from it by distillation). Your Highness and his citizens may also burn this oil in lamps when at work

Fig. 15. Crude-oil winning and refining (after Agricola, De re metallica, 1556).

in their houses, just as it may be used by firework makers in place of linseed oil for fireworks and gunpowder, for I have found that it burns far more fiercely than linseed oil.

With this I will close and leave others, more qualified than I, to conduct further investigations, to gain more experience and to collect useful data."

The pamphlet ends with the remarkable words:

". . . produced at Ingweiler on 18th May, 1625. Any interested reader desirous of this oil, as prepared by the author, may enquire of the printer where he may procure it."

Whether Volck, about whose life we have no further knowledge, had therefore a small distilling plant at Lampertsloch and whether his patron,

the Count of Hanau, granted him the monopoly for the operation of this seepage, we do not know. It would certainly be possible to deduce something of the sort from his words. It even becomes probable when we consider that in 1576 Archduke Ferdinand of the Tyrol granted Abraham Schnitzer the right to exploit the Seefeld oil shales and to make oil from them by dry distillation. Shortly after the publication of Volck's pamphlet Italian oil was mentioned by Ariosto as produced in various shallow hand shafts near Ferrara, quickly followed by fresh discoveries at Monte Chiaro, Piacenza and Montechino (1640), and on his travels in 1649 Bandinus came across such hand-shafts in Roumania and Galicia.

Comparing Volck's statements with those of a famous technologist such as Agricola, we read in the twelfth book of the latter's "De Re Metallica" (1556): "Liquid bitumen (petroleum), which floats in large quantities on the water of springs, brooks and rivers, is skimmed off with buckets and other utensils. Small quantities are collected by means of goose wings, linen cloths, bundles of hair and other things to which the bitumen readily clings, boiled in large copper and iron boilers, and evaporated in the heat. It is used for various purposes and many people mix it with pitch or with old cart grease—in order to reduce its toughness. The bitumen does not become hard, however, not even with the boiling in vessels."

In his "De Natura Fossilium" (Basel, 1546) he writes:

"The Saxons and Germans from Transylvania usually evaporate the mineral oil by boiling it in copper and iron pots. It readily ignites during this process, but can be extinguished by means of wet linen cloths."

Compared with these summary remarks by the most important writer of the time on chemical technology, Volck's pamphlet stands out by virtue of the acumen of its author, who obviously personally looked for possible practical uses of crude oil and the distillate therefrom in directions which had not occured to his contemporaries.

We are well-informed on the developments at Pechelbronn by Paul de Chambrier's book. [1] Paul de Chambrier (1866-1937) was in charge of the "Pechelbronner Oelbergwerke", and it was he who after experiments on the absorbent properties of oilsands (1897) started driving shafts down to the oil strata of Pechelbronn, washing the oil out of them, so that it could be pumped up and refined (1917). This method of mining for petroleum was then introduced at Wietze (1919) and even in Roumania (Sarata-Monteoru, 1923). [2] Pechelbronn now boasts 6 shafts, galleries totalling 345 km in length,

[1] Paul de Chambrier, Historique de Pechelbronn, 1498-1918 (Attinger Frères, 1919).
[2] P. M. Edmond Schmitz, Paul de Chambrier (Revue Pétrolifère 8 oct. 1937).

with 680 pumping units which deliver the oil to the refinery. We will therefore only discuss the highlights of this development.

In 1734 Jean-Théophile Hoeffel published his treatise on the oil of Lampertsloch, [1] pointing out that Volck's treatise had not produced practical results, as the oil continued to be collected from the seepage by the old-fashioned method of skimming the water. This yielded 500 grammes a day. There is no doubt that the word "Beach" does not refer to "Bach" (brook) but to "Pech" (mineral pitch). [2] Thus a contemporary book on the physical

Fig. 16. Smelting bitumen from bituminous rocks "Destillatio per descensem" (after Agricola, De re metallica, 1556).

geography of France [3] refers to "Bech flowing like well-water from a hill near Clermont, which Bech is black, viscous and glue-like and can be used for many things." Later authors and even the workmen at the refinery about 1840 still speak of "Bechelbronn".

[1] Jean-Théophile Hoeffel, Historia Balsami Mineralis Alsatici seu petrolei vallis sancti Lamperti; Der Hanauische Erdbalsam, Lampertslocher Oel- oder Baechelbrunn (Fac. of Medicine, Strassburg, 1734).

[2] P.-M. Edmond Schmitz, Les Mines d'Asphalte, origine du mot Pechelbronn (Revue Pétrolifère No. 806, 1938, pp. 1297-1299).

[3] J.-Chr. Beer, Ausführliche und grundrichtige Beschreibung des Königreiches Frankreich . . . (Chr. Riegel, Frankfurt und Leipzig, 1690).

Hoeffel prepared lamp oil from the Lampertsloch crude by repeated distillation, which in his primitive apparatus involved heavy cracking. About 1745 the first well was sunk, followed by others in the period between 1763 and 1785. The "mountain balm" was used mainly for medicinal applications. The mining at Pechelbronn was in the hands of the "manufacture de la Sablonière", and Antoine le Bel, a lawyer and "député", who had been a shareholder of this "manufacture" since 1741, became sole proprietor in 1768, when Madame de la Sablonière sold him her shares. From that year until 1889 Pechelbronn remained in the possession of the Le Bel family. In 1775 Valmont de Bomare [1] reports that Pechelbronn was producing 10-12 pounds of oil a day, and gradually these wells and those on other sites in the region began to be exploited more carefully, especially after 1785. [2] In 1795 Loysel, député de l'Aisne, prepared a report [3] on the importance of the French bitumen refineries "which are only to be found in the provinces of the Jura and the Lower Rhine. The mineral grease or asphalt made there serves as a substitute for lard and other animal fats, for instance as a lubricant for vehicles in order to diminish friction. The importance of the factories had been clearly shown during the recent (revolutionary) wars, when there was a shortage of animal fats used in the manufacture of candles and soap". "The Pechelbronn mines" consisted of shafts sunk near seepages and galleries, from which oil-bearing sands were dug to be washed to yield the crude.

The timbered shafts were rarely deeper than some 20 m and the interconnected galleries formed an underground labyrinth where the bituminous sand containing some 3-4% of bitumen was extracted. Some of the shafts served to bring the bituminous sand to the surface by means of baskets and pulleys but several were used as ventilation shafts. However, in summer work was usually stopped as the humidity underground and the heavy fumes made the work impossible. The sand was treated with water in a series of boiling vats, the oil skimmed off and placed in a refining vessel.

The increase in production is evident from the survey given by Baquol [4] in 1849. He tells us that "the bituminous mine" at Lobsann was discovered in 1789 by Mr. Rosentritt and "is now being exploited on a large scale. A bituminous limestone is now extracted, which serves for the manufacture

[1] Valmont de Bomare, Dictionnaire Raisonné Universel d'Histoire Naturelle contenant l'Histoire des Animaux ,des Végétaux et des Minéraux, etc. (P.-G. Simon, Paris, 3rd edit. Paris 1775, 9 vols., vol. I, pp. 375, 672) see also page 42.

[2] J. A. Le Bel, Notice sur les gisements du pétrole à Pechelbronn (Paris, 1885).

[3] Pierre Loysel, Observations sur les salines du département de la Meuse, de celui du Bas-Rhin . . . (Journal des Mines 1796, vol. IV, cah. 13, pags. 31-35).

[4] Jacques Baquol, Dictionnaire géographique, Histoire et Statistique du Haut et du Bas-Rhin (Strasbourg, 1849).

(by destructive distillation) of mineral oils, pitch and asphaltic mastic. The oil obtained is white and limpid like well-water or yellow like vegetable oil. Both types serve as lamp oil, the former more particularly for lamps in dwellings, the latter in factories, workshops and streets". He also informs us that Lampertsloch "is in full production"; several veins were discovered by J. A. Le Bel in 1839. The products marketed are:

1. "Asphaltic grease", a natural product containing some 60-80% of petroleum;
2. Thick grease shipped in barrels;
3. Thick grease of superior quality shipped in boxes.

These three qualities are used for the lubrication of wheels, axles of vehicles, bearings on machines, etc.

From the first asphaltic grease, naphtha and petroleum are manufactured for lighting, for the manufacture of rubber, bitumen for mastic and the dry bitumens called Judaean bitumen. The peasants of the Lampertsloch region use asphaltic grease for greasing their horses' shoes, and apply it to the wounds of animals, particularly in summer when they are tormented by flies. They also use it on burns, inflammations, etc., because of its soothing effect.

The first quality, the "asphaltic grease", was a pure petroleum product (crude oil) but the latter two qualities were prepared by mixing the hot washed oil obtained from the sand with 20% of a soap obtained by treating pork lard with washed plant-ashes, thus obtaining a mineral grease. Lampertsloch produced some 100 tons of the "asphaltic grease" by the end of the eighteenth century. A Paris periodical, the "Annonces, Affiches et Avis divers" of April 11, 1774, contains the following advertisement:

> "The stores of asphaltic grease for lubricating cart wheels is now in the Rue Montorgueil in the "Golden Compass". This grease is much superior to lard, it has a longer life, is incorruptible and friendly to iron, it strengthens timber and its smell is excellent. Price: 8 sols a pound."

The asphaltic grease could of course be distilled to obtain a lamp-oil and the residue could be used as a mastic for careening ships. Still the market for lamp-oil was too small and the crude was sometimes burnt as such. Attempts to produce lampoil from this crude and to refine it by filtration through river sand, charcoal and lime were made by Charles Lefebvre of Sulz-sous-Forêt (1816) but trials at Lampertsloch failed to show the economy of the process, even though Lefebvre was able to produce an excellent solvent for paints from the crude. [1]

[1] Description des machines et procédés spécifiés dans les brevets d'invention, de perfectionnement et d'importation dont la durée est expirée (Vol. XIII, pp. 231-234, pl. 22, figs. 1-2, Paris, 1827).

A proper market for lampoil from petroleum was not created until the advent of good lamps for burning such oils early in the nineteenth century.

We are also informed that the seepage at Schwabweiler was first noticed in 1830 and that in 1838 a well was sunk which produced a copious flow of oil at a depth of 22 metres. Schmitz [1] has drawn the attention of historians to the work of Gustave Adolphe Hirn (1815-1890), who belonged to a family of manufacturers of printed cotton goods and who had worked as an engineer in their Logelsbach factory since 1834. As early as 1843 the firm reports important savings in fuel and ingredients for lighting "effected by their engineer G. A. Hirn". From 1847 onwards Hirn reported to the Société Industrielle de Mulhouse his observations and experiments with the water-wheels of his factory at Logelsbach. It was decided to reproduce them, 500 francs being allocated for this purpose, and in March 1854 the Chairman Emile Dollfuss asked Hirn to report upon his experiments. This he did a year later. [2] This report constitutes a milestone in the history of the theory of lubrication and the manufacture of lubricants.

The Société Industrielle de Mulhouse seems to have been interested in lubrication for many years, for at its meeting on June 29, 1831 Charles Dollfuss had demonstrated an apparatus for the comparison of fuels and lubricants, which consisted of a copper cylinder with a small hole in its conical bottom. This earliest viscometer was also used by Hirn, who called it a "fluidosomètre". It is certain that Hirn's firm was exploiting a small plant for the manufacture of lubricants and kerosine by distilling the crude of Lampertsloch with superheated steam as early as the beginning of 1854, and perhaps even in 1853. Hirn refined the distilled lubricants by treating them with sulphuric acid.

At the meeting of the same society on May 28, 1856 the firm of Pfeiffer and Rivoire displayed two qualities of "liquid mineral lubricants", made by them, possibly by dry distillation of natural asphalt or heavy crude, for it was noticed that they still had a "strong smell of naphtha" which it was hoped to remove after further experiments.

Meanwhile, developments were continuing at Pechelbronn. Frédéric-Achille Le Bel built the first modern refinery in 1857 and directed it until his death in 1867, when his son Joseph-Achille Le Bel succeeded him. As we saw from Baquol's report he had already taken a keen interest in promoting the development of Pechelbronn. One of the most brilliant of Würtz's pupils

[1] P. M. Edmond Schmitz, L'Epopée du pétrole (Pichon et Durand-Auzias, Paris, 1947). — Introduction à l'étude des travaux de Gustave Adolphe Hirn sur les lois de frottement (Matière Grasses, 25 May and 25 June 1914).

[2] G. A. Hirn, Etude sur les principaux phénomènes que présentent les frottements médiats et sur les diverses manières de déterminer la valeur mécanique des matières employées au graissage des machines (Bull. Soc. Industr. Mulhouse 1855, Nos. 128 & 129).

in Paris, he made a big name for himself in science, as the founder, together with Van 't Hoff, of stereo-chemistry. He was also one of the most brilliant pioneers of modern petroleum refining and wrote many essays and books on this subject. He and his three sisters directed the works with great efficiency. By 1880 Pechelbronn was processing 1,000 tons of crude, in 1886 7,000 tons. However, political circumstances did not favour the development of this family business, which on February 22, 1889, was converted into a joint-stock company, the "Pechelbronner Oelbergwerke", of which Paul de Chambrier became the first managing director.

2. *Lobsann*

The asphaltic limestone of Lobsann was discovered by Eyrinis in 1735, but in the records his business-partner de la Sablonière over-shadowed him completely (see Chapter II). Thus Valmont de Bomare mentions only the latter even when discussing the rock asphalt of Neufchatel! [1] Oil seepages were discovered near Lobsann in 1756, but they never acquired any importance. In 1817 exploitation of the asphaltic limestone was conducted on a larger scale, [2] for the method described by Valmont was too costly. This consisted in boiling the crushed "mineral pitch" (maltha, pix mineralis) with water and skimming off the refined bitumen in the way such bitumen had traditionally been produced at Wietze and Seyssel.

The Lobsann mines, like those of nearby Sulz-im-Wald, passed into the hands of the Le Bel family, who sold then in 1817 to the firm of "Müller et Compagnie Société de Mines d'Asphalte de Lobsann, Soultz sous Forets, Basse Alsace", which was owned by the Dournay brothers, who developed the mines on the lines of the Seyssel methods. This is what Payen [3] had to say about the Lobsann asphalt, which enjoyed a good reputation in the early history of asphalt roads:

"Mr. F. Dournay, owner of the mines of Lobsann, department of Bas-Rhin, has sent us two samples of his products. One of these is known by the name of bitumen or mineral tar, and the other is named bituminous mineral mastic, or simply bitumen mastic.

It was as a result of an initial report on the products of this able manufacture that the Société d'Encouragement realised how useful it would be to have a more

[1] Valmont de Bomare, Dictionnaire Raisonné, vol. VII, p. 27.

[2] Ch. Pictet, Mémoire sur les emplois des produits bitumineux de Lobsann (Bibl. univ. des Sciences, Genève, 1819). — Daubrée, Description géologique et minéralogique du Bas-Rhin (1852). — Notice sur le gisement de bitume du lignite et du sel dans le terrain tertiaire des environs de Pechelbronn et de Lobsann (Annales des Mines 1841). — Mémoire sur le gisement de bitume, de lignite et de sel dans le terrain de Pechelbronn et de Lobsann (Paris, 1867).

[3] M. Payen, Mémoire sur les bitumes, leur exploitation et leurs emplois utiles (Huzard, Paris, 1824).

complete report on the subject. The three committees have been kind enough to entrust the drafting of this report to me.

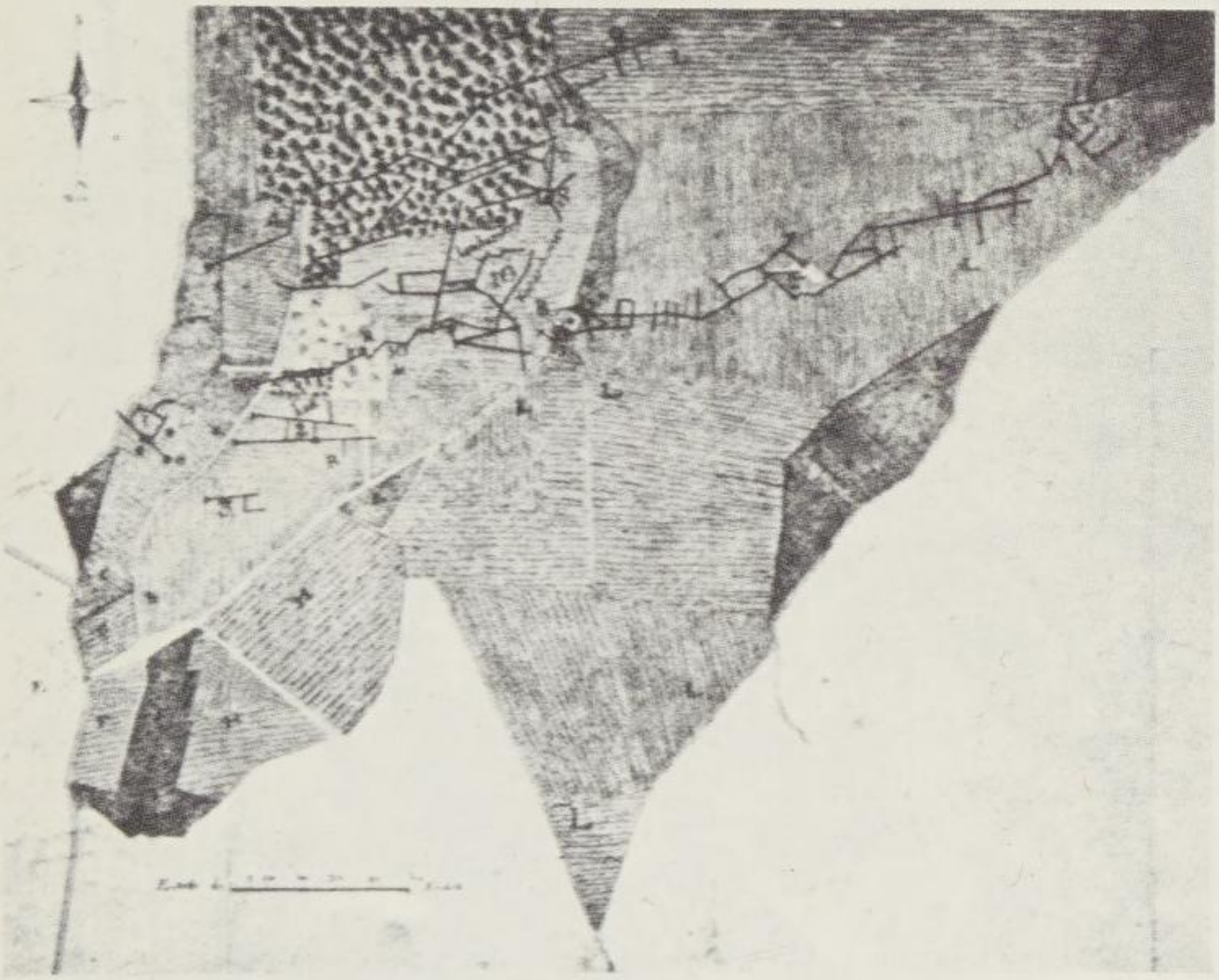
The bituminous sand at present being exploited at Lobsann belongs to a Tertiary formation; its bed is horizontal; it extends three hundred metres from north-west to south-west, and four hundred metres from south-west to north-east; it is from thirty to eighty centimetres thick.

In its bed lies a seam of a very tough bituminous limestone, containing about 0.12 bitumen. It is estimated to be from ten to fifteen centimetres thick; and it is used in the manufacture of mastic, to which we shall revert later.

Glutinous bitumen and bituminous mastic are obtained in Mr. Dournay's factory by the following processes: Seventy-five kilograms of ore are cast into smelting pans of one hundred and sixty litres capacity half filled with water which is brought to the boil. The petroleum, having become fluid and lighter because of the heat, separates out, extraining a large proportion of maltha; this bituminous mixture rises and floats on the surface of the liquid; it is stirred almost continuously with pokers, in order to facilitate the separation of the bitumen, and as it passes almost completely into the maltha state, it thickens and is easily removed as scum by means of iron skimmers. After boiling for three hours, the sand yields no further appreciable quantities of bituminous substances. It is then taken out of the boiler and replaced by fresh quantities which are treated in the same way. Two workmen can operate six boilers at a time. They use three thousand six hundred kilograms of ore in twenty-four hours, and extract about two hundred kilograms of bituminous maltha.

Bitumen, prepared as described above, still retains a fairly large amount of water and earthy substances. To be purified it is placed in a large smelting boiler of four thousand litres capacity and it is heated fairly fiercely to evaporate the water content. The earthy substances, impregnated with bitumen, are deposited at the bottom and the purest bitumen is decanted. Six hundred kilograms of raw bitumen loaded at once and processed in this way, produce three hundred and fifty to four hundred kilograms of refined bitumen, which is equivalent to a little more than 5,000 kilograms of the ore used. The refining process keeps one workman occupied for thirty-six hours. The maltha obtained is black or very dark brown in colour, highly stable at normal temperature; at lower temperatures it is hard and less supple. It is opaque, very tenacious, liable to soften in the rays of the sun. By raising its temperature it can be made fluid enough to spread it by brush and to tar the surface of various materials. By distillation paraffin oil can be drawn from it; the residue is a hard and brittle kind of asphalt. It is by combining the refined maltha with the bituminous limestone found in the same time that M. Dournay prepares bituminous mastic, the second product of the Lobsann mines. To prepare it, five parts by weight of bituminous limestone are mixed as intimately as possible with one part of refined maltha. The bituminous limestone is first of all dried and crushed to powder, then it is thoroughly mixed with the melted maltha by adding it part by part.

Throughout the whole process the temperature is kept at a fairly high level; on completion of the mixing, the mastic has the consistency of a thick mortar. It is then taken out of the boiler and moulded in wooden rectangular parallelepipeda. It solidifies, is removed from the moulds and is then despatched in this form. The mastic blocks are one foot six inches or four hundred and eighty-six millimetres long, one foot or three hundred and twenty-two millimetres wide, and about four inches or one hundred and eight millimetres high. Each one weighs from thirty to thirty-four kilograms."



Plan of the "Le Bel asphalt mine" with its shafts and galleries (1795).

Naphtha Bituminis eſt liquidi genus: in mare manat
Montibus è Siculis, fluidiſq; ſupernatat vndis:
Spongiâ eam excipiunt Nautæ, expreſſamq; recondunt
Ollis, vt varios hominum ſeruetur in vſus.

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Collecting oil with sponges on the seashore of Agrigento (Drawing by J. Stradanus (1523-1605), etched on coper by Ph. Galle (1537-1612)).

PLATE X

CHAPTER SEVEN

THE OIL OF ST. CATHERINE (MODENA)

The Italians never forgot the seepages which the classical authors had discussed. [1] This we learn from the letters which Boccone [2] published together with his comments, which book gives an excellent survey of the petroleum eepages and related phenomena known round about 1700.

Boccone not only discusses foreign seepages such as Barbados, Puerto Principe (Cuba), Valona (Albania), Cephalonia (Greece) and others, but also many locations in Italy. In Sicily there was a seepage near the church of St. Febronia in the town of Patti which was stopped by the earthquake of 1693. Other seepages are near Bucali and Casciu (near Agrigento), Vivona, Mistretta and Roccani near Savoca (Messina). Several seepages occur near the coast of Agrigento, Catania and Messina. We have indeed a drawing by J. Stradanus (1523-1605), from which Ph. Galle (1537-1612) made a copper plate (Plate X) showing how the oil on the surface of the sea near Agrigento is collected by fishermen with the help of sponges. Inland near Agrigento the Tertiary Order of the Franciscans skim such "olio di naphta" from the Fontana delli Strazanti. Other seepages are found near Petralia, but they are always subject to volcanic action such as stopped the seepages near Agrigento some sixty years before Boccone collected his evidence.

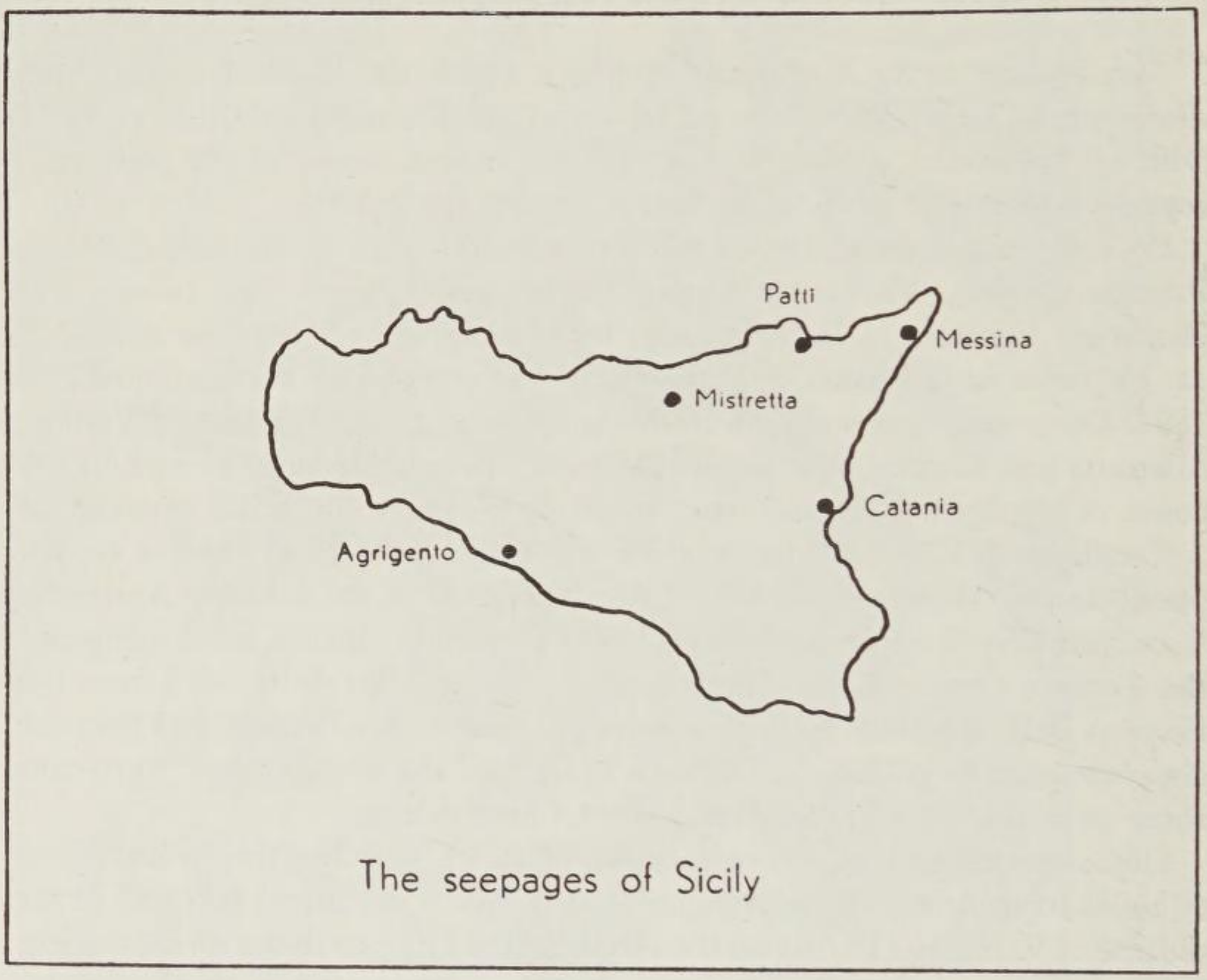
Other bituminous substances are found about 10 miles from Castro and 60 miles from Rome. This "mountain pitch" (pece di Castro) is found in the diocese of Veroli and in August the sun melts the bitumen in the rocks, causing it to ooze forth. Its consistency is equal to that of wax, amber, or oil of resin. It is still mixed with earth but is melted, sieved and then sold in Rome for 2-3 florins a pound. It was used for many diseases and mixed with wax and other ingredients in unguents. Boccone compares it with the bitumen found at Sacca (Sicily) which he also maintains has been formed by volcanic action deep down in the earth.

A thick crude oozed forth in a well in Puteoli and at Rocca di Mezzo near

[1] R. J. Forbes, Petroleum and Bitumen in Antiquity (Studies in Ancient Technology vol. I, Brill, Leiden, 1955).

[2] P. Boccone, Museo di Fisica (Venezia 1697, pp. 32-38, 161-178).

Aquila (Naples). This "Olio Puzzolo" is used for painting and careening ships. The same type of thick oil is found in the Val di Non (Trentino) on a plot belonging to the Count of Thun. We have more reports on wells in Puteoli containing petroleum; there is a passage on such a well in the report by R. Benjamin of Tudela (1166), [1] and there are further reports in the handbooks of the famous eleventh-century physicians of Salerno. These wells were believed to heal all kinds of diseases, particularly skin diseases.



The seepages of Sicily

Fig. 17.

Boccone also draws attention to the fact that the intermittent gas-wells called "mofete" (in Sicily they are signified by the term "macalubi" derived from the Arabic) containing sulphurous gases, often throw up oil or occur near seepages, for instance at Mineo (Sicily) a town which is also often called "Naphtia" because of the petroleum found on its beach. Near Agrigento such gas-wells and seepages occur on a plot of infertile land five miles away

[1] L. Grünhut & M. N. Adler, Die Reisebeschreibungen von R. Benjamin von Tudela . . . (Kauffmann, Jerusalem und Frankfort 1903, vol. II, p. 9).

from the towns. Two wells near Perugia on the mainland containing traces of oil and mofette occur nearby.

A clear, white and thick waxy petroleum was found in a well near Viterbo in 1690. The local chemist analysed it and found it very much like olive oil, as it did not have the usual sulphurous smell; its medicinal properties were manifold.

The more important seepages, however, were to the north between Piacenza and Bologna in the hills between the Appenines and the river Po, where we still find the major oilfields of Italy. Boccone reproduced in his book a letter which a canon named Antonio Vivi wrote him on September 6, 1694 on the "Olio di Sasso", as petroleum was often called in his days. Vivi mentions a spring of mineral water with outstanding medicinal properties situated in the territory of the Duke of Modena at the foot of the castle of Brandola and surrounded by wells in which petroleum floats on the surface of the water. One of these is at the foot of the mound of the castle of Baranzone. It is some 30-40 braccia (ells) deep and there a vein was discovered lately from which the petroleum oozed forth on the water. The oil did not flow regularly but mainly in spring and autumn, and also when the water ran dry in hot summers.

In the same region of Modena there was a hill near the castle of Monte Gibio on the side of which three seepages constantly give out small quantities of petroleum which is neither white nor red, but in between the two colours. This oil, which has a pleasant odour, is the one bought by Germans and other inhabitants of northern countries, and also held in great esteem by the papal court of Rome.

Two miles beyond Sassuolo Vivi saw a "voragine", a gas well which emits gases, flames and ashes, and which formed a crater of earth around its mouth of 40 ells in diameter. On March 10th, 11th and 12th, 1693, there was a violent eruption, and the cattle and horses had already refused to go near it three days previously. At the same time the wells of Monte Gibio stopped oozing oil but resumed their flow afterwards. The gas well also cast forth remains of purple-snails and other shells; hence Vivi supposes that the substance from which the oil was formed is a product of the sea and deposited during the Flood.

Boccone, commenting on Vivi's report, waxes lyrical on the medicinal properties of the Olio di Sasso which is also called St. Catherine's Oil, a liquid bitumen formed by heat and fermentation from "fat earth" in the bowels of the earth. It is used for paints, for embalming and unguents, and cleanses the human body of skin diseases, dissolving obstructions in the intestines with facility. It is usually cast forth from the earth together with water and is skimmed off by the peasants. There are two types, a white and a red petro-

leum. The white petroleum is found near Miano de Medesano, some 12 miles from Parma. The red petroleum oozes forth at Vizzola without water, but most of the other wells of red petroleum cast it out together with water. This red oil is produced at Fornovo, Ozzano Rubiano, S. Andrea, Lesignano, Torre, Sasso and Castellarano. It flows more abundantly in spring and autumn, for the fermentation takes place mostly in winter and perhaps in certain places in spring, but in spring and autumn temperatures promote an easy flow from the veins at the earth's surface. In certain cases it pays to deepen the wells. Boccone reports that one well when deepened gave out more than 1,000 pounds of oil over a ten days period, at the end of which the walls caved in and the old rate of production of a few pounds per day was resumed. Near Querzola and Sasso, some 15 miles from Bologna, the earth is saturated with oil, and inhabitants of this large town dig pits upto 40′ deep and then collect the oil as do the inhabitants of Parma near their hometown.

Many of these seepages and gas wells were known well before the days of Boccone, a fact which is demonstrated in the coats of arms of many old Italian towns and the ancient Latin author Pliny (Nat. Hist. II. 240) mentions that "a flame comes out in the district of Modena on the days appointed as sacred to Vulcan". Thus when the Emperor Frederick II gave Salsomaggiore a charter he granted this town a coat of arms displaying a salamander in the midst of flames. Nearly two hundred years later, at the turn of 14th and 15th centuries, the Ducal Chamber of Parma issued a concession for the exploitation of the seepages of Miano de Medesano.

Two generations later the seepages near Modena were visited by Francesco Peregrino Ariosto. He wrote an essay on the oil of Monte Zibio [1] in 1460, which circulated in a few copies in manuscript form until it was printed by Ramazzini in 1690. Ariosto lived during the reign of Borso d'Este (1413-1471) (uncle of the famous Beatrice d'Este) who was created Duke of Modena and Reggio by Frederick III in 1452 and who in 1470 was made Duke of Ferrara by Pope Paul II. Under his reign Ferrara enjoyed a period of peace and prosperity. The Duke established a printing press at Ferrara, surrounded himself with learned men and famous poets and authors. He protected industry and commerce and ruled with great wisdom.

We know very little about Ariosto. He may have been closely related to the famous author of Orlando Furioso, the poet Ludovico Ariosto (1474-1533) who hailed from Reggio in Aemilia. Francesco Ariosto was born at Ferrara and became a professor of law and philosophy at the University of Ferrara. In thanking him for his essay on the Oil of St. Catherine Duke Borso d'Este addresses him as "Jurisconsulto" and "potestati Monticuli" which shows

[1] Franciscus Ariostus, De Oleorum Principis Olei Monzibini ortu et Virtute (1460).

that he was a lawyer and the mayor of "Monteculi"; this town cannot be the present Montecúccoli, but was probably Montécchio near Parma. Ramazzini informs us that he found a manuscript copy of Ariosto's essay in the Este Library bound in one volume with some of his other works, being a "Dialogus de Divina Providentia", a "Sermo de Purificatione B. Virginis" and an "Epistola ad Sixtum IV Pontificem de rebus summo in Pontificatu suo agendis"

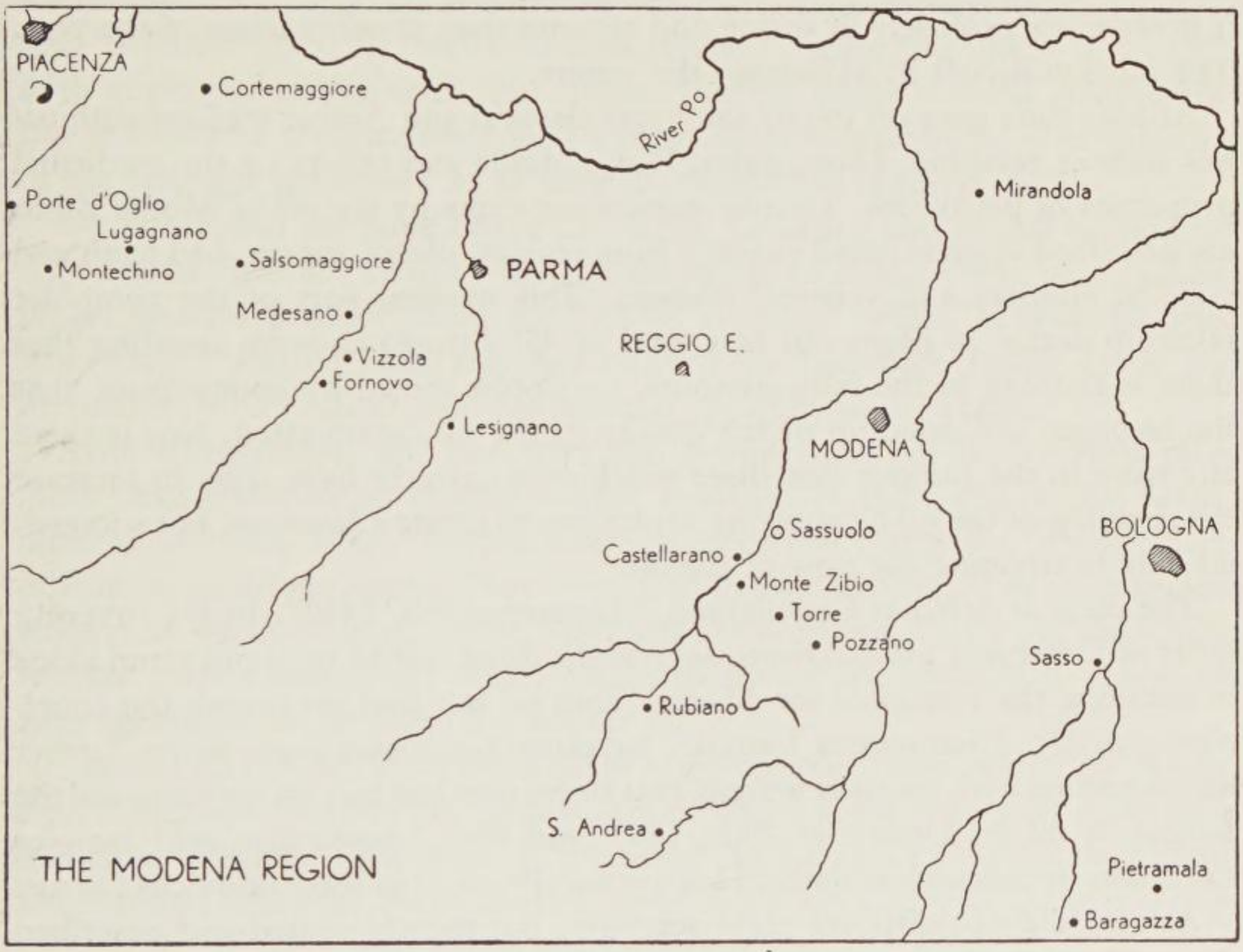


Fig. 18.

The latter essay gives us a further date in Ariosto's life, for this Pope Sixtus IV (Francesco della Rovere, 1471-1484), in conjunction with the Republic of Venice, started the Ferrarese War (1482-1484) threatening Ariosto's master. He must still have been alive at about this time and some authorities [1] state that he died in 1492. On the other hand in Ramazzini's time this entire volume, including the essay on the petroleum of Monte Zibio, was registered as the work of the poet Ariosto!

In Ramazzini's edition Ariosto's essay occupies 46 pages. The introduction addressed to Borso d'Este in the usual flamboyant style of the period informs

[1] A. Franklin, Dictionnaire des noms, surnoms et pseudonymes latins (Paris, 1875, p. 41).

the Duke that Ariosto will discuss the oil of Monte Zibio which is of eminent value for its medicinal virtues are rightly famous in other countries. In certain regions of "Saxony" there are similar oil-seepages, but the quality of these German oil is definitely inferior to that of Monte Zibio. The first chapter then deals with the seepage of Monte Zibio and describes the neighbourhood in great detail. From the hill of Monte Zibio flow three streams of oil, which collects on the waters of a little rivulet nearby. Its smell is very fragrant and it flows more profusely in spring and autumn than at other times of the year. The oil is collected by skimming the waters.

Ariosto then goes on to cite the usual classical and Arabic medical authorities such as Serapion, Dioscorides, Pliny, Mesue and others on the medicinal properties of petroleum. Twenty miraculous cures by the oil of Monte Zibio are described in great detail ranging from scabies, ulcers, cancer, bad teeth and colic to epilepsy and venereal diseases. This medical part of the pamphlet takes up nearly 36 pages out of a total of 46! Ariosto ends by asserting that there is nothing in the false rumours, no doubt spread by competitors, that the seepages had dried up or the quality of the oil deteriorated. Nor is there any truth in the rumour that three mischievous youths have tried to increase the trickling of the oil by applying explosives to create a fountain, but succeeded only in stopping the flow of the oil.

The essay is dated at Castellarano, "December 9th, 1460". In his covering letter of December 1462, Ariosto assures the duke that he does not stand alone in extolling the virtues of the Monte Zibio oil but that his friend, the court-physician Dr. Hieronymus Castello, supports his contentions. From further letters printed with his essay we read that Borso thanked him for his essay and the sample of oil on December 29th, 1463, and that Ariosto also sent samples to certain friends such as Father Hieronymus Bendedeus and Ludovicus Carrus.

Ariosto did not discover these seepages, but merely visited and described them. The oil of Monte Zibio appears as early as 1440 in the apothecary's tax list of the town of Vienna, and in later documents one regularly meets the "Oglio di Sasso", "Oglio Santo", "Olio Montesible", "Olei Montezibini" or "Oil of St. Catherine". It is sometimes said to come from the "land of Sybia" (and even Syria!). This confusion of Zibio with "Syria" no doubt stems from certain details of the legend of St. Catherine, then still common knowledge. We are told that after the saint was beheaded "angels bore her body unto the Mount of Sinai, and buried it honourably, and continually oil runneth out of her bones which healeth all maladies and sicknesses, and she suffered death under Maxentius the tyrant; about the year of our Lord three hundred." [1]

[1] (Jacobus de Voragine), The Golden Legend of Lives of the Saints as done into English by William Caxton (1483) (Dent, London, vol. VII, p. 225).

In Italy too, petroleum is mentioned in the inventories of apothecaries' shops before Ariosto. [1] Thus we are informed that Margarita de Buis acting on behalf of the heirs of Antonius de Ferrariis de Caxellis in 1441 leases for the period of nine years a "stacionem et spiciariam" near the Ponte gate in the Parish of San Marino at Pavia [2] to Manfredino de Caponago and his three sons. The inventory was carefully drawn up by Johannespetrus de Lege, a spice-merchant of Pavia and among the materials mentioned in this list we find "asphalti" (No. 91) (no doubt asphalt) and "olleum petrollium" (No. 137), both evaluated at one soldo per ounce. Further study of local documents [3] (the inventories of pharmacies, etc.) will probably reveal that local exploitation of the seepages dates back to at least the fourteenth century.

We know that the fame of the Oil of St. Catherine had spread beyond the Alps in the fifteenth century when a merchant of Amiens was punished for illegal medical practice using the "oil of Amiano" which he had imported from Italy. [4] Indeed from this day onward we find both Italian crude and petroleum from Gabian sold for medical applications in France.

Ariosto, therefore, did not start this propaganda but his detailed essay must have contributed much valuable evidence in the form of the twenty miraculous cures, which the producers of medicinal petroleum in other parts of Europe could not quote. They continued to use the quotations from ancient authors as we shall see (Chapter VIII) and not until much later did they begin to base their evidence on actual local experience, for instance in the much later pamphlet on Gabian oil (Chapter I).

The full text of Ariosto's manuscript was preserved for posterity by Bernardino Ramazzini (1633-1714), professor of medicine at the university of Modena and later at Padua. [5] He printed "Francisci Ariosti, De Oleo Montis Zibinii, seu Petroleo agri Mutinensis libellus" after receiving a copy of the manuscript

[1] G. Alcati & V. Bianchi, Farmacie Pavesi nella prima metà del quattrocento (IN: Raccolta Di Scritti in onore di Giulio Cenci, Pisa, 1953, pp. 7-50). — V. Valenti, Ordinamento e Farmaci dello „Speciaria" della corte ducale estenze dal 1551 al 1558 (Minerva Farmaceutica 1956, nos. 5 & 6)

[2] Archivio Notarile Pavia (A.N.P.) — Not. Agostino Baracchi VI. 346.

[3] P. Sella & E. P. Vicini, Inventari di farmacia modenesi del secolo XIV (1327-1345) (Boll. Stor. It. d. Arti Sanit., Roma 1932, pp. 143—164). — G. Carbonelli, Inventario di una farmacia di Pinerolo (1398) (Archiv. di Farmacognosia e Sc. Aff., Roma, 1912). — G. Carbonelli, Inventario di una farmacia recanatese del 1384 (Att. R. Dep. St. Patr. delle Marche, 1916). — O. Viana, Un inventario di farmacia veronese del 1463 (Att. Accad. Ver. ser. IV, vol. XIII, Verona, 1916, pags. 89—107). — Un inventario di farmacia veronese del 1411 (Att. Accad. Ver. ser. IV, vol. XXI, Verona, 1920. pags. 183—209).

[4] J. Girard, Un peu d'histoire (Journal du Pétrole no. 136, 1906, p. 137).

[5] B. Ramazzini, Opera Medica (curavit J. Radius, Leopold Voss, Leipzig, 1828, vol. II, pp. 289-352). — De fontium Mutinensium scaturigine (Modena, 1713) (Later reprinted in: Opera Omnia, 1716 and later editions).

from Jacob Oliger of Copenhagen on September 28th, 1690. Magliabecchio, librarian of the Grandduke of Tuscany, whom he thanks in his preface, had put him on the track of this valuable essay which he then found in the Royal Library of Copenhagen. Magliabecchio was always eager to put ancient knowledge buried in unpublished manuscripts to use and Oliger had been most obliging, said Ramazzini in his letter of June 15th, 1698 to the abbott Felice Viale, professor of botany at Padua, to whom he dedicated this Modena edition (1698). The Ariosto essay is printed in full with all the letters we have mentioned and Ramazzini adds some observations of his own. While he was at Sciandiano he inspected the Monte Zibio seepage "which is not far from the river Schianca (Secchia) and near its confluence with the rivulet Ruvina". Very full details of the entire neighbourhood are then given. The crude produced is of a dark-red colour and is sometimes called "black balm". Ramazzini denies that the original production was anything like 40 lbs a day; it amounted on an average to some 8 lbs, but it is true that this is now less, some 6 lbs a day.

According to Ramazzini this fall in production is due to volcanic action, for which the region has indeed been famous since Antiquity. Had not Pliny [1] reported an "earthquake", which looks to us rather more like an eruption and explosion of natural gases in the year 91 B.C.? He had said: "I find in the books of the lore of Tuscany that a vast and portentous earthquake once occurred in the district of Modena; this was during the consulship of Lucius Marcius and Sextus Julius. Two mountains ran together with a mighty crash and then retired with flames and smoke rising between them to the sky. This took place in the day-time, and was watched by a large crowd of Knights of Rome with their retinue and passers-by. The shock brought down all the country houses, and a great many animals in the buildings were killed". Ramazzini also holds that because of this volcanic action the quality of the oil is no longer quite the same as in the days of Ariosto though it is still very effective as a balm for skin diseases and scabies and as a purgative. He compares it with other types of petroleum known in his day, for instance with the crude of Sumatra, of which Bontius wrote, [2] which "oil of Achin" was even sold in Italy as we shall see in Chapter VIII. His conclusion is that its virtues may have been grossly exaggerated in certain respects but that it still has very valuable medical properties, as many later authors were to confirm.

[1] Pliny, Nat. History II, 199, cap. 85. — A. Frassoni, De thermarum Montis Gibbi. Natura, usu atque praestantia tractatus (Cassiani, Modena, 1660).

[2] J. Bontius, Hist. Nat. & Medicina Indiae Orientalis (Leiden, 1658, Lib. II cap. 1).

We have a later description of the Italian seepages in a work by Pierre Belon dating back to 1553, [1] which refers to the "Monte Zibio oil".

The famous French essayist Michel de Montaigne (1533-1592), when journeying to the baths of Lucca and tormented by stone and gravel, visited the oil region in 1580-1581, according to the account of his journey found much later and published in Paris in 1774. He saw seepages at Baragazza and

Fig. 19. Transporting Monte Zibio oil in standard flasks (From the Antwerp pamphlet of 1540).

Pietramala and assures us that petroleum from Modena was used for lamps, paints and varnishes and also as a medicine.

There is also a reference to Italian crude oil in Barba's treatise on mining

[1] Pierre Belon, De admirabili operum antiquorum et rerum suspiciendarum praestentia, (Paris, 1553, Lib. III, cap. V, pags. 43-49).

and metallurgy.[1] This seventeenth-century author is mainly interested in mining and metallurgy in the New World but the ninth chapter of his book deals with bitumens in general and their occurrence all over our globe. This is what Barba has to tell us:

"On the liquids called bitumens.

Bitumen is one of the substances which are the most harmful to minerals, especially in the process of smelting, because it burns them and reduces them to slag. It is, however, uncommon to find it mixed with ore; but when that does occur, one must be careful to separate them before subjecting the ore to the heat of a fierce fire.

There are twelve kinds of bitumen: asphalt, pissasphalt, naphtha, gagate stone, jet, ampelites, maltha, Thracian stone, coal, yellow amber, ambergris and camphor. All these bitumens derive their oiliness from the fat of the earth. Some people think camphor is the tear or resin of the tree called Capar on the isle of Zebat; that yellow amber comes from a grass akin to pennyroyal, since they are frequently found together; and this ambergris comes from a large fish of the whale species. But that is pure speculation; and it will always be true to say that there are liquids which originate in, and issue from, the bowels of the Earth and which are truly bitumens.

Asphalt is collected on the lake of Sodom or Dead Sea; in Judaea at the southern end of the river Jordan which flows into this sea three leagues from the city of Jericho. Asphalt is nothing more than a kind of grease which floats on the waters of this lake. The wind and waves carry it to the shore where it thickens and hardens. This grease looks like pitch; but it is harder and of a better colour. Before the fire of Heaven had consumed Sodom, Gomorra, Adama and Seboin, the fertile valley where these loathsome cities were situated abounded in wells of this bitumen, as is testified by the Holy Scriptures in Genesis 14, verse 10. They are found in several other parts of the world where they are burned instead of oil for light. In Peru, where man's attention is occupied solely with the search for gold and silver, they have little interest in anything else; however, asphalt does not fail to be known because it exists in abundance in the mountains of Los-Chiriguanas on the frontier of Lomina. This country is only seldom frequented. Its inhabitants have not been pacified; that is why they are called Warrior Indians.

Pissasphalt is a natural mixture of asphalt and pitch, as is clear from its smell. Failing the genuine article, it is counterfeited with pitch.

Naphtha is a bituminous spirit which is white and occasionally black. It is what is called petroleum, so familiar in medecine on account of its property of curing intractable pains caused by cold. Naphtha attracts fire as a magnet attracts iron so that it is inflammable at a considerable distance. Dr. Matthiolus relates an incident in this connection of which Count Hercules of Ycontrarii, a gentleman of Ferrara, was an eye witness.

This count had on his estate a well from which some naphtha was drawn with the water; but much was lost through the cracks in it, produced by the action of time. He instructed a mason to repair the well. The latter asked for a light, the better to see the work that had to be done. A candle enclosed in a lantern was passed down

[1] Métallurgie ou l'art de tirer et de purifier les métaux, traduite de l'espagnol d'Alphonse Barba (edit. Gosford, Paris, 1751, 2 vols.) (Vol. I, pp. 30-36).

to him. The naphtha soon drew the fire through the little holes in the lantern, caught fire instantaneously and, with a roar as loud as the report of a heavy gun, hurled the mason from the hole, blew him to pieces and flung aside a tree branch, placed across the well. The Count himself told the story to Dr. Matthiolus who included it in his commentary on Dioscorides.

Asphalt and pissasphalt melt over a fire like wax or pitch; in this respect they are different from gagate stone, jet and coal which burn away like larch or any other wood.

I have not been able to ascertain so far whether there are any of these bitumens or others in Peru. But I am convinced they would be found if they were known and that people would certainly take the trouble to look for them."

Gosford, the editor of this French translation of Barba's work added several other French essays on metallurgy to the second volume of this edition. One of these is a "Restitution of Pluto" written by the baroness Martine de Beau-Soleil (Paris, 1640), and it tells us that waters which have been in contact with bituminous rocks or seepages have the following properties:

Bituminous waters fill the brain with fumes, irritating the nervous system and the sensations, overheat and enervate the womb, the bladder and large intestines chiefly, and are good for dropsy."

Gosford also publishes a "Paradox that the metals are alive" written by William Granger of the town of Dijon, Royal Physician (printed at Paris in 1640), the sixth to ninth chapters of which discuss the "nutrition and growth of metals by means of some outside force". Granger believes that metals and other minerals grow naturally in mines and that they are constantly replenished in Nature if left alone for some time. The same holds true, according to Granger, for salts and bitumens, for "as we have observed, after extracting them from mines or quarries, they will again become available after a short time".

Pierre Pomet, [1] contemporary of Ramazzini and Boccone devotes a long passage to the petroleum of Modena:

"Italian naphtha is a variously coloured fluid which flows down from a rock situated in the valley of Montefestino in the Duchy of Modena; this oil has been known to us only these last few years through one Roque Foura, a native and inhabitant of a village called Prat near Briançon in the Haut Dauphiné, from whom I got the account set down below and who sold me the different kinds of Naphtha which I have.

Italian or Montefestino naphtha comes out of a rock on a mountain whither it is conducted by underground veins, and it is collected as an oil of various colours by means of certain conduits and boilers which separate it, or to let the Duke of Sara and Darcé and Marquis of Arpia in the Duchy of Modena, to whom the rock

[1] Pierre Pomet, Histoire générale des drogues (Loyson et Pillon, Paris, 1694, Pars III, lib. iii, cap. xvi).

mentioned belongs, better understand, he has had channels or copper pipes prepared and placed directly so as to catch the oil coming out of the rock, and by means of these pipes the oil drops into these copper boilers from which it is collected; this oil changes colour according to whether it is situated close to, or away from, the light of the sun, for the kind which comes out on the sunny side is colourless like water and is considered the best, the kind at the side is clear and red like wine, the kind following is yellow, then green, and finally the kind at the other side of the rock opposite the colourless variety, is black.

The white naphtha which we normally call white petroleum oil, both by reason of its whiteness, transparency and beauty and because it cannot mix with anything at all, is lighter than anything you may add to it, always rising to the surface, also resembling sulphur by its strong, pervasive smell, which makes it highly volatile and liable to catch fire, a fact that should serve as a warning to those who sell it and make them distrust it as though it were gunpowder.

Because of the great qualities of this oil I am unable to say anything about it here, referring the reader to the printed material which the said Roque Foura has had published about it, to which those desirous of knowing about them may have recourse. As for red, yellow and green naphtha, they are so little used that we do not see any at all; and moreover the fact is that the Italians mix them into the black variety before sending it to us, and that is what causes the petroleum oil supplied from Italy to be of a clear red, yellowish colour, instead of being black and thick as it comes out of the rock, and to have not too penetrating a smell of sulphur; since this oil is rather expensive, some substitute for it an adulterated petroleum oil, as will be seen in the following chapter."

From this passage we must conclude that Ramazzini's publication of Ariosto's essay had again focussed attention on the Modena oil and that its use beyond the frontiers of Italy was again of sufficient importance for French dealers to stock it.

In 1715 Boulduc [1] described the "oil of Ferrara" in these words:

"Apart from artificial and vegetable oils, that is to say, those extracted from plants, there are natural oils emanating from the earth generally called petroleum oils, or petroleum, because they emerge from cracks in stones and rocks. As far as can be seen they are the result of underground fires which have raised or sublimated the finest parts of certain bituminous substances. These parts have become condensed into a spirit as a result of the coolness of the rock caverns where they have accumulated and afterwards escaped through the cracks and openings which the nature of the ground has afforded them. Petroleum is thus a bituminous liquid which differs from solid bitumens such as asphalt, amber, etc., only in its fluidity. Naphtha which is a bitumen or liquid, or at any rate very soft, is the same thing as petroleum.

Up till now, more petroleum has been found in hot countries than in others. Olearius, for instance, states that he has seen more than 30 wells near Scamacchia in Persia. However, if the petroleum were formed by underground fires, these fires are not peculiar to hot countries. There are varieties of petroleum in France,

[1] Boulduc, Sur l'huile de Pétrol (Histoire de l'Académie Royale des Sciences 1715, pp. 19-24).

Athanasius Kircher's sketch of an eternal lamp fed by a leaden pipeline from an oil seepage or subterraneous reservoir (After the Dutch translation of his Mundus Subterraneus, "D'Onderaardse Weereld", Amsterdam, 1682, Vol. II, pag. 92).

A tous ceulx q̃ ces p̃sentes lettres verrõt ou orrõt Salut scauoir faysons Cõme moy Guillaume Grangier Licencie en loix Vicaire apostolique a Geneue en lieu de monseigneur le Duc de Ferrare comme p le commandement de mon dict seigneur duc de Ferrare ceste fueille nõmee Petroleum laquelle souloit estre faicte a Viterbe au Roche par la deffence de mon dict seigneur le nommee Oyerschle assise a cinq journees de Rome. Laquelle fueille monsieur seigneur de Ferrare a faict esprouuer par pluseurs grãs docteurs en medecine tãt de Rome cõme de Naples et de Boulogne lesquelz medecins ont trouuee laditte fueille fort bonne et proffitable en les maladies et infirmites q peuuent venir au corps humain. Ainsi cõme il appert par les attestacy cy apres enseignans faictes et disposees par lesdictz docteurs cy dessus mys les grans et nobles vertus et proprietez de laditte fueille.

C Et premieremẽt dict Auicene au second liure de son Canon en parlant de Petroleo q̃ ceste fueille est chaulde et seiche iusq̃s au quart degre et est subtile et resolutiue appertenant aux applicatiõs et fomentacions dont souuent grãs maladies. Et est moult profitable a la douleur des hanches nõmee sciatiq̃ et a toutes douleurs de iointures quelz elle viẽne de cause froide quelz on en frotte les hanches et autres lieux mal obeissans le soir au soir et au matin. Pareillemẽt laditte fueille vault aux douleurs et froideur des oreilles mais quelz ne soit fumee de nature perilleuse de cause froide en mettant de ceste fueille deux ou trois gouttes dedans les oreilles et vng peu de coton au iour quant on se veult coucher.

C Item ceste fueille vault a la cape des yeulx et a tous ceulx qui decliẽt aux yeulx en distillant vng petit dedans tout et pour mettre vng petit au dessus de linge mouille en eaue pose dessus dessus.

C Item celle fueille contre vne maladie du pouls nommee Asmetique passion cest a dire deffault ou difficulte dalaine et a lestomach nommee apostomacum vne dragme de ceste fueille auecques deux onces de eaue de plaine tiede.

C Item celle appaise les douleurs du ventre comme colicq passion paralysie torsions des boyaulx et autres semblables douleurs.

C Item boyt vne dragme de ceste fueille consomme et degaste les ventositez de la vessie et oste la froideur de la matrice aux femmes et par ainsi les dispose a conception mais il en y est de deux manieres cest assauoir de la blanche et de la noire dont la blanche est la meilleure cy dessus.

C Item ceste fueille dict Dioscoride en son traicte des medecines a ces anciens philosophes sont conuenues par ceste raison et experience de ceste fueille a ses operations et vertus et lappellent pleine vertu et vraye mere. Les autres lappellent fueille diuine. Les autres fueille de sapience. Les autres fueille solaire. Les autres fueille saincte. Toutes ces noms prebent des grãs proprietez et vertus de ceste fueille naturelle de laditte est a noter que est trouuee en temps iadis pour vng cas fortuite en partie semblable a ceste fueille selon ledict docteur a vertus calefactiue resolutiue penetratiue et consommatiue des superfluitez.

C Item celle est bonne a Epilepsie que on appelle le mal sainct Jehan en frotant la nuque du col et au matin et espessement par longtemps au matin auec deux onces de eaue de plaine.

C Item celle vault a Paralysie en frotant la nuque dicelle fueille et les parties flesches.

C Item vault aux gens qui perdent ou ayent faulte de memoire par habondance de fleumes en vsant dicelle comme dessus.

C Item celle vault a la douleur de la raate des reins et de la vessie de la matrice des douleurs du dos des gencives et gouttes froides de espritz des yeulx quant procedent de froideur en frotant celle fueille au soir au matin et en beuuant dicelle ioint tout est.

C Item dicelle dict Dioscoride a son second liure quelle a ces proprietez dessusdictes et dict quelle est des grans secrets des philosophes.

C Item celle vault a congnee douleurs et playes fraictes de couteau celle incarne et consolide les soubtes playes.

C Item appert que ceste fueille a vertus contre maladies procedans des causes froides car si vous prenez quatre gouttes dicelle et les mettez dedans vng voyre de eaue froide et alumez le feu et celle ardra. Parquoy appert quelle est tres chaulde et puissante.

C Item celle vault et est bonne contre toute morsure de beste venimeuse comme de lasbeste fueille et la mesnerue cuicte du lin aigre et les fueilles ensemble et en frotez la playe elle tyrera le venin dehors et garde de enfler laditte playe.

C Item pline dict Plutarque et Dioscorides en son Canon vsitans ou chapitre de Petroleo ensemble toutes les vertus deuãdictes dicelle vng seul tant en ydee cõme la pierre quelle vous prendrez de la poulbre de la pierre et se nomme Lapis tiacis et vous trouuerez chez les apotiquaires et les fueilles se prennent ensemble et pareillement en la vesse ou en la vessie aues vne seringue celle rompt et degaste la pierre et engendre celle est dure grosse et informe. Mais auãt celle on doibt ensuyure deux ou trois iours le lieu au tour de la vesse de vne coction de mauues auec fueille de rue pour emolir la pierre et eslargir appelle et ouurir les pores et conduictz de la vessie et de la verge par la ou la pierre doibuent passer. Et si on ne trouuoit point de lad poulbre on pourra user dicelle quelq chose comme au cas cy dessus dit vng peu la chaleur de lad fueille cõme est eaue darcacangit ou autres semblables.

C Item est a noter que quant vous prendrez de ceste fueille ou la boire prendre auecq quelq eaue froide et marine cõme eaue de Lucerne burgoise ou eaue de Chrestofuel et semblables.

C Item celle vault et est bonne contre toutes douleurs des dentz quant on prend de laditte fueille chaulde et en frotez la ioe et en prend vng peu de coton et le boutez dedans laditte fueille chaulde et le boutez sur la dent qui faict mal.

C Item laditte fueille vault contre la fievure que est dedans le coups de la pisonne quant on prend vne dragme auecq deux onces de eaue dendiue ou dyscope quant la fievure veult prendre et boyre et frotez lestomac et les cuisses de lad fueille chaulde toute pure.

C Item celle vault contre la douleur du stomach quant la pisonne se sent enfrouble ou espoins et plain enflez et ne peut digerir de manger pres de lad fueille en frottez la poitrine de celle chaulde le soir quant vous vous coucherez et vous vous trouuerez bien le lendemain.

C Item celle vault et est tres bonne contre les vers des enfans et de toutes gens en se frottant lestomac et la poitrine auec lad fueille chaulde.

C Item les choses dessus escriptes sont veritables et esprouuees par la faicte et maniere dessus est dicte. En tesmoing de Nycolas baillet Capitaine de laditte montaigne. Messire Francoys arnoste docteur en medecine de la cite de Ferrare et messire Jehan Guillaume docteur en loix et conseil dudict seigneur de Ferrare et moy Guillaume Grangier ay signees ces presentes par le commandement de mondict seigneur. Et ioinct vous du moys de May. Lan mil quatre cens quatre vingtz. Donne par copie reficiee du propre original. Sans dec. Ainsy.

The Geneva pamphlet (1490) (State Archives, Geneva).

though certainly only in the southern provinces. There is some in Italy in the Duchy of Modena and it is the best we have here. Monsieur Boulduc considered it a piece of good for true to have some that was beyond all suspicion of having been adulterated, for rare and little known drugs are almost always so, and he took advantage of this good fortune to make observations which surely pertain to genuine petroleum.

The petroleum comes from a most barren valley in the bailliage of Montefestino, 12 miles from Modena. It was a Ferrara doctor, François Ariosto, who discovered it in 1460. At great cost, and even danger, different canals from which three different kinds of petroleum flow were dug in the district.

The first is almost as colourless, clear and fluid as water, possessing a very pungent, penetrating and not unpleasant smell. This is the most perfect.

The second is a clear yellow, less fluid than the colourless kind, and possessing a less pungent smell.

The third is a blackish red, of a thicker consistency, and possessing a somewhat unpleasant smell of bitumen. The Italians export hardly any of the first kind, and we would be more than delighted if they supplied the second kind in its pure state, but often, by mixing a small quantity with the third kind and adding some volatile oil like turpentine, they pass it all off as the first type.

The smell of this petroleum is so strong and pungent that people say it is noticeable two kilometres away from the source.

Monsieur Boulduc has made the following observations about the petroleum of the first, or colourless, kind. It catches fire over a candle without coming into contact with the flame, and when heated in a vessel, it attracts the flame of the candle even though raised several feet above the vessel and after that is completely burnt up, i.e. a volatile vapour which rises from this liquid bitumen goes to the candle flame, catches fire which extends to the entire volume occupied by the vapour and reaches the petroleum in the vessel. It burns in water, and doubtless that was one of the elements of Greek fire.

It floats on top of all spirits, even the redistilled essence of wine, which is heavier by 1/7.

It mingles perfectly with the essential oils of thyme, lavender and turpentine, although it is mineral and these oils are vegetable. But perhaps for that very reason the mineral and the vegetable are not so different in this respect, for the vegetable oils were at one time mineral, since plants have drawn them from the soil.

When stirred violently petroleum produces many bubbles, but it returns to its normal state more readily than any other spirit. That comes from the fact that the air in the petroleum is dissolved of necessity in a unique manner, and the particles of the spirit by their very nature are not able to tolerate any other. Actually, the particles of an oil enjoy a certain cohesion, their filaments or little branches interlocking in such a way that the air which they contain is forced to conform to them.

Petroleum covers a surprisingly large area on water, one drop spreading out for over a fathom, and in this state it shows up colours, i.e. its little threads become prisms.

The heaviest frost makes no impression on it. Paper soaked in petroleum becomes transparent only for a few moments, and ceases to be so as soon as it has been dried in the air.

In 1701 [1] we discussed oils which catch fire when mixed with an acid spirit from

[1] W. Homberg, Recueil de l'Académie des Sciences, 1701.

which the phlegm or moisture had been thoroughly removed. The same effect might have been expected of petroleum, but it does not occur; only acid spirits mix perfectly with it, and give it a very thick consistency. Those oils which catch fire are, as we have said, essential oils of aromatic plants of the Indies, and it is not to be wondered at that petroleum does not possess their properties.

The redistilled essence of wine, which is the great dissolvent of sulphurs and oils, does not make anything of petroleum, even after it has been allowed to stand for a long time.

Monsieur Boulduc has not been able to extract any phlegm or spirit of salts from petroleum either by distillation in the vapour bath or in the sand bath. All that rose was oil, and a very small quantity of a thickish, somewhat brown substance remained at the bottom of the retort.

When using petroleum in medecine, one can only leave it as it is. It is a physic ready made by Nature, like several others of which we have spoken, and on which art has no occasion to expend its restless endeavour."

This passage is remarkable because it contains the first report on scientific attempts to fractionate and evaluate a crude oil, however childish the results may seem to us now.

In 1736 a Swede named Psilanderhjelm visited the seepages of Montechiato and his remarks were published in the bulletin of the Académie des Sciences of Paris: [1]

"In Italy the same Monsieur Psilanderhielm saw (and reported to Mr. Geoffroy) the simple method used for a little while to extract petroleum from mount Ciaro (Montechiaro?), some 12 Italian leagues from Piacenza. There are grey slates on this mountain, almost horizontally deposited, interspersed with clay and a kind of selenite which appears to be of a calcareous nature. Holes are dug into these slates perpendicularly until water is found, and then the petroleum that was trapped between the layers of slate and in their crevices oozes out and drops on to the water of the wells that were dug. When sufficient petroleum has collected in them, as after a week, people go and collect it in brass bowls. It is mixed with water, but it is easy to see that it is a simple matter to draw it off.

Petroleum keeps well on the water in these wells, whereas in stoppered vessels it attacks the corks generally used and evaporates to a great extent.

This oil is transparent and colourless, whereas that of Modena is yellow, and that of Parma brown.

It is highly inflammable.

When a well is no longer productive, a hole is dug into the mountain at another spot.

As more is extracted than apothecaries use, it is thought it might be used for steeping and hardening wood. The local squire has successfully tested it on resinous woods like pine and fir."

The famous seepage of Montezibio gradually declined in importance. When Vandelli [2] visited it in 1755 and 1759 some two generations after Ramazzini,

[1] Histoire de l'Académie Royale des Sciences, Paris, 1736, p. 56.

[2] Domenico Vandelli, Tractatus de Thermis Agri Patavini, Accessit Bibliotheca Hydrographie & Apologia contra Cel. Hallaeum (Patavii, Typographia Conzatti, 1761). — Domenico Vandelli, Analisi di alcune acque medicinali del Modense (Padua, 1760).

he found that there were only two small trickles left on the mountainside. However, in the course of the eighteenth century several new seepages had been discovered, Montechiaro and further west, between Parma and Piacenza, near Montechino and Miano de Medesano. This latter seepage is often referred to as "Amiano" and it is mentioned by this name in de Saussure's essay [1] on its composition and properties, probably one of the earliest analyses of petroleum. De Saussure describes this oil as a "very liquid, transparent and yellow fluid with a specific gravity of 0.836." Three distillations yielded a naphtha with a boiling point of 85° C which seemed identical with that prepared from the crudes of Gabian, Val de Travers or Seyssel by distillation and cracking. The solubility of the crude in several solvents is then reported. Mineral acids are found to have little effect on it, except when hot, neither is there any appreciable action of potash or lye. The inflammability of the vapours is very characteristic, and de Saussure adds a warning to those using petroleum. Such warnings were not futile, for the crude of Miano de Medesano and of Fornovo di Taro were used in street lighting in Genoa, Parma and Borgo San Donino as early as 1802.

By the turn of the nineteenth century more scientists turned to the study of the phenomena of the gas- and oil-seepages of Modena. The biologist Lazzaro Spallanzani is reputed to have studied them and Alessandro Volta, of electricity fame, was deeply interested in the methane gases of Pietramala and the northern Appenines. During the nineteenth century more and more studies on this region were published and the future author of a more complete history of this old oilregion should do well to consult these older handbooks [2] and the local town-archives of Modena and other localities of the province of Emilia, which are sure to yield abundant material.

[1] Theodore de Saussure, Recherches sur la composition et les propriétés du naphte d'Amiano dans les états de Parme (Ann. Chim. Phys. vol. III/IV, 1816, pp. 314-321).

[2] Vallisneri, Antonio, De corpi marini che sui monti si trovano, della loro origine, ecc., 1728. — Antonio Stoppani, Corso di Geologia 1871, Il Bel Paese 1875. — E. F. Fairman, Treatise on the Petroleum Zones of Italy, London 1868 (Italian edition by Achille Donzelli, Bologna 1876). — V. Zopetti, Sull'industria dei petroli nelle provincie di Parma, Piacenza e Pavia (Relaz. del Servizio Minerario nel 1881, Roma 1883). — Rivista del Servizio Minerario nel 1890 (Firenze 1892). — Carta indicante la distribuzione dei pozzi ordinario o trivellati e delle sorgenti naturali di petrolio, gas infiammabili ed acque minerali nella zona petrolifera dell'Emilia (Firenze 1892). — A. Del Prato, Petroli ed emanazioni gazose nelle provincie di Parma e Piacenza (Parma, 1899). — P. D. Pietro, Il petrolio di Monte gibbio (Modena) nella storia della Medicina (Minerva Medica (Torino) vol. XLVI, 1955, no. 28). — Il petrolio di Monte gibbio: specialità medicinale (Galeno, vol. V, 1957, no. 2).

CHAPTER EIGHT

ADVERTIZING THE MEDICINAL PROPERTIES OF PETROLEUM

In the days when the supplies of crude oil depended on a few small seepages only and when bulk transport methods had not yet been invented, some appreciable local consumption as fuel or source of light was sometimes possible but sales over a large distance depended on the transport and marketing of small quantities of packed oil at a relatively high price. No wonder that such sales are concentrated on the medicinal application of petroleum. Here the old centres of production such as Modena and Tegernsee seem to have created substantial markets on which they not only proclaimed the merits of their products in the form of broadsheets but they also competed vigorously for these markets.

With the introduction of paper manufacture into Western Europe and the advent of printing new techniques became possible which were more effective than the sales talk of the pedlar of the past. Broadsheets were now printed extolling the quality and properties of the crude oil. Like most modern pamphlets for patent medicines they do not contain very precise instructions on the diagnosis of the diseases to be treated by well-specified applications of the petroleum product sold. They lean heavily on traditional opinions of the medicinal value of the products discussed, some of which may be centuries old and quite out of date. The weight of authority is very prominent in such pamphlets, the opinion of doctors and professors of medicine is quoted as gospel truth regardless of the fact that they may have been proved wrong by later scientists or that they are constantly misquoted. Famous names are to make up for the utterly phantastic claims made in the pamphlet on the author's own authority. The more of such famous names which appear the better, the pamphlet often takes the form of a notary's deed to make it look more official and the quotation of sometimes wholly imaginary works.

Although the early broadsheets of the late fifteenth and early sixteenth centuries do not differ much in character from modern pamphlets on patent medicines they do still deserve our interest for the sake of the illustrations

and the facts regarding early petroleum technology which they reveal to us on analysis.

Four important examples of such broadsheets were printed in the period from 1480 to 1550, which deserve to be quoted in full and a close survey made of their contents.

The first of these was found many years ago in the State Archives of Geneva (P. H. IIe série No. 107 bis) and it was probably printed in that city around 1480. This broadsheet is printed in gothic characters on a sheet measuring 35 by 22 cms., but the upper third of the sheet is taken up by a woodcut, depicting a doctor applying petroleum externally to a wound in the forehead of a rather dismal-looking patient sitting in front of him.

The French text of this pamphlet (see Appendix A) takes the form of a deed drawn up by William Grangier, notary of the Grand Duke of Tuscany and Ferrara, with Nicholas Basset, "captain of the said mountain", Dr. Francesco Ariosto, physician and his fellow notary, Jehan Vaîlam, as witnesses. It describes the invaluable medicinal properties of the crude oil of the Montesible, five days' journey north of Rome, in these words:

"To all those who shall see these present letters, Greeting; we are making it known how I, Guillaume Grangier, bachelor of laws, apostolic notary and secretary to his Eminence the Duke of Ferrara certify by order of the said Duke of Ferrara that this oil called petroleum issues forth from a mountain or rock by the will of God and Our Lady. This mountain, which is called Montesible, is situated five days' journey from Rome. The said Lord of Ferrara has had this oil tested by several great doctors of medicine, both of Rome and of Naples and Bologna, and they have found the said oil to be very useful and profitable in combatting the cold ailments to which the human body is prone. Thus as it appears from the articles following hereafter, made and drawn up by the said doctors in order to show the great and noble qualities and properties of the said oil.

And firstly Avicenne states in the second book of his canon at the appropriate chapter "De Petroleo" that this oil is hot and dry to the fourth degree and is a keen effective resolvent for the bodily oppilations and obstructions from which serious illnesses often derive. It is very useful for the pain in the hips named sciatica and for all pains in the joints caused by the cold, if the hips and other painful parts are rubbed with the oil in front of the fire night and morning.

Similarly the said oil is good for pains and deafness of the ears, provided that the deafness is not natural but only due to the cold. Two or three drops of the said oil should be put in the ears at night before retiring and the ears stopped with a piece of cotton wool.

Item, this oil is good for leucoma of the eyes and for water running from the eyes, by pouring a little into the eye and then placing a small rag of linen soaked in water applied as above.

Item, it is good for a lung disease called asthmatic passion, that is shortage of breath or difficulty in breathing and with a persistent cough, when one dram of this oil is taken with two ounces of luke warm hyssop water.

Item, it relieves stomach pains such as colic passion, "yalicque" cramps in the bowels and other similar pains. Item, if a dram of this oil is drunk it eats up and annihilates flatulence in the bladder and dispels frigidity of the uterus in women and thus prepares them for conception, but there are two types of this, namely the white and the black, of which the white is the better for this.

Item, thus speaks Mesué the evangelist of doctors that the ancient philosophers agreed both from reason and experience that this oil has secret ways of working and they call it "oleum secretorum iuvamentorum". Others call it divine oil, others oil of wisdom, others blessed oil and yet others holy oil and all these names originate from the properties and qualities which it possesses. And the oil of which we speak is a natural oil and is found in sulphurous parts and in the sweat of a stone (petra) for which reason it is called petroleum and is formed when the fatness of the earth and of the water is converted by the action of heat into sweaty parts and according to the said doctor this oil has warming, resolvent and penetrative properties and the capacity to reduce excess fat.

Item, it is good for epilepsy, which is called St. John's disease, by rubbing it into the nape of the neck night and morning and by taking one dram in the morning with two ounces of sage water.

Item, it is good for paralysis if rubbed hot into the nape of the neck and the affected regions.

Item, it is good for forgetful people or those who have lost their memory from an excess of phlegm, if it is applied as above.

Item, it is useful for pain in the spleen, in the back and knee joints, blisters on the feet and pains in the eyes when these things are caused by the cold. The treatment consists in rubbing the said parts with hot oil night and morning and in drinking it as stated.

Item, Serapion told his servant that it possesses the above-mentioned properties and said that it was one of the great secrets of the philosophers.

Item, it is good for scurvy, scabs and for knife-wounds. It heals and knits the said wounds.

Item, it appears that this oil has properties making it effective against illnesses resulting from the cold, for if four drops of it are taken and put into a glass of cold water and the appropriate spot is inflamed, it will burn. It appears from this that it is very hot and powerful.

Item, it is effective against the poisonous bite of an animal. The said oil should be taken and mixed with vinegar and the two boiled together. If the wound is rubbed with it the poison will be drawn out and the wound prevented from swelling.

Item, Platearius, Cassius Felix says in his "Circa instans" in the chapter "de Petroleo", in addition to all the above qualities, that it is a sovereign remedy for a gall-stone, if powder from the stone named Lapis lincis is taken, which is to be obtained from the apothecary, and they are boiled together for a short while. If the mixture is then injected into the bladder through the penis by means of a seringe it will break and dissolve the stone, however hard, large and compressed it may be. Before this, however, the parts around the genitals must be fomented for two or three days with a digestion fluid of mallows and olive oil in order to soften the stone and enlarge and open the ducts and passages of the bladder and penis, through which the stone will have to pass. And if none of the said powder could be found something suitable for the case could be taken such as arcacange water or the like, by lowering slightly the heat of the said oil.

Item, it should be noted that when you take some of this oil it should be taken with some cold and sticky water such as bugloss chicory water or Cherfeuil water or the like.

Item, it is valuable and is good for all manner of toothaches, if some of the said oil is taken hot and the cheek rubbed with it, by taking a little cotton wool, immersing the end in the said warm oil, and applying it to the aching tooth.

Item, the said oil is good for the fever in a person's body, if a dram with two ounces of endive or hyssop water is taken. When the fever comes on some of the said pure hot oil should be drunk and some rubbed into the stomach and the back.

Item, it is good for bellyache and when the person feels cold or cramped and has such a pain that he has no appetite for food at all, some of the said oil should be taken and rubbed hot into the chest at night on retiring and he will feel well the next day.

Item, it is valuable and very good for children's and adults' worms if the hollow of the chest is rubbed with the said warm oil.

Item, the things set forth above are true and verified by the mode and manner here described.

Witnessed by Nicolas Basset, captain of the said mountain, Master Francis Ariosto doctor of medicine of the city of Ferrara and master John Vaïlam, doctor of laws and counsellor to the said lord of Ferrara, I, William Grangier, have signed these present documents by the command of my said lord, on the sixth day of the month of May, fourteen hundred and eighty. Submitted in a copy extracted from the original.

Laus deo. Amen."

Hence the virtues of this petroleum or Oil of St. Catherine are supported by quotations from Avicenna, Mesue, Sérapion, Platearius, Cassius Felix and others. Dr. Joannes Platearius of Salerno (Italy) lived during the eleventh century and enjoyed great authority in the Middle Ages. His famous Practica Brevis already leans heavily on some of the other authorities quoted in our pamphlet. Platearius is convinced that "rock oil or petroleum is formed when the richness of the earth and waters is transformed by the action of heat into a fiery substance. It is formed on rocks because it sweats through them and oozes forth from them, and it can be formed on walls. Its black colour will turn white later by dint of thorough baking". In the Saliternian collection there is an essay on the baths of Puteoli (balneae puteolana) [1] which eleventh-century document mentions the healing qualities of petroleum "which swims on the waters there".

The most important of Platearius' authorities was Avicenna (Ibn Sînâ, 980-1037 A.D.) whose works embraced the heritage of Greek medicine mixed with new discoveries by Arab doctors and pharmacists. Mesue was the Latinized form of the name Ibn Mâsawaih, an Arab physician of the early ninth

[1] De Renzi, Collectio Salernitana (Napels, 1853, vol. II, pp. 32, 114, 123, 351, 405). — Giacosa, Magistri Salernitani nondum editi (Torino, 1901, p. 37).

century (died in Samarra in 857), who also translated many Greek medical works into Arabic and Syriac. Cassius Felix of Carthage was a Roman physician who lived about 450 A.D. and who represents the direct link between Plate-

Fig. 20. Physician treating a head-wound with petroleum (The Geneva pamphlet, 1490).

arius (and the Salernian school) and Greek and Roman medicine. Serapion of Alexandria, who probably lived in the first half of the second century B.C. founded the empirical school of medicine, rejecting every kind of medical dogmatism of his day, and was therefore led to try many popular remedies

in spite of their absurdity. Klebs [1] correctly points out that this type of witness, quoted by the author of our pamphlet, lived many centuries before 1480 but the weight of their authority remained valid for centuries to come. Nor is it likely that the author has really read the original editions of the works of the famous physicians he quotes. In his days such extracts as appear in this pamphlet illustrating the possible application of petroleum were already to be found in the common pharmacological handbooks such as the French "Arbolayre", and the "Grant Herbier en francois" or the famous Hortus Sanitatis Deutsch of Peter Schöffer (Mainz, 1485) and its descendants, the Hortus Sanitate of Johann von Cube (Mainz, 1485) and the Hortus Sanitatis of Jacobus Meydenbach (Mainz, 1491). Thus we are told in the latter 1491 edition: "Cassius Felix reports on petroleum. Petroleum is the oil from the rocks. It is found on volcanic sites. However, it is transformed by the fat of the earth and the power of heat into fire. It is also found in rocks, either between them or enclosed by them. We also find it below the sea's surface". This theory of the origin of petroleum is repeated for several centuries and combined with more modern ones.

It would seem that our author culled his quotations and supporting evidence from such handbooks rather than from original study of the authors mentioned in his pamphlet. This use of second-hand evidence to support the claims of the medicinal virtues of petroleum is even more evident from the second pamphlet (Fig. 21) written in German (see Appendix B), which turned up in the University Library of Prague (Ms XVII. D. 10). The text runs:

"The quality of the noble oil, which is used for many bodily ills.

Petroleum is an oil which by the grace of God and the effect of the sun oozes from a mountain of rock in the land of Tussia on a high mount named Sibia. It is not man-made, as many people maintain. By reason of its great virtue it is called balsam by many people; and it is also called St. Catherine's oil. Because of it no poisonous creeping thing or snake stays on the mount, although such vermin are very common in those parts. The virtue of this balsam oil, here described, banishes them.

Cassius Felix and Avicenna say that petroleum is hot and dry to the fourth degree.

Also it has the virtue of loosening, attracting and consuming the matter which comes from the cold. Likewise for cramp, irritations, trembling or wasting of the limbs, it is of some help, if the oil is applied, says Avicenna in the Fifty Books (Qânûn).

Also it is beneficial for aches in the feet, called podagra or gout.

Also for pains in the hips and for chill and gout, if it is applied.

It is the best of all remedies for gall-stone if the hips and genitals are rubbed with it, says Platearius. He who pants with a cold or a cough of long standing, let him rub the chest with it and it helps.

For the maladies of the womb which are caused by the cold this oil is a great help.

[1] A. Klebs, Une annonce médical de pétrole en 1480 (Bull. Soc. Franc. Hist. Méd. vol. XVI, 1922, Nos. 9/10, pp. 391-396).

Die tugent des edelen Oles. welches man gebrauchet fur vil gebrechen des leybes. ꝛc.

Petroliū ist ein öll. das von den gnaden gottes schwitzet auß einem steinem pergk. durch wurckūg der sunnen. in dem landt Tussia. auff einē hohen perg genāt Sibia. vñ ist nicht gemacht als etzliche sprechē. darumb wirt es durch seiner grossen tugēt willen von vil lewtten Balsam genāt: auch wirt es genant sant Katherinen ol. Darūb pleibt keyn gifftiger wurm noch Schlange an dem perge. welches gewurbine in den landen ser gemeyn sein. Dieß haylsamē oles tugent hie beschriben sindt vertreybet

¶ Cassuis felix. Auicenna sprechen das Petroliū sey heyß vñ truckē biß an den vierdten grad.
¶ Item sein tugent ist auflösen vnd zu im ziehen vnd verzeren die matery die von kelt kumbt.
¶ Item für den krampff vnd Reissen zittern oder Sch wunden der glider / als mit dem öll geschmirt es hilfft. spricht Auicenna in libro Pentecteū.
¶ Item es dient auch für den wetagen der füsen genant Podegron oder ziperla.
¶ Item für die wetagen der lend / vnd wider die kalt sucht / vnd dem gegicht darmit geschmirt.
¶ Für den steyn ist es die aller best ertzney die lenden vnd oß dem gemechte damit geschmirt / spricht Platearius.
¶ Wer das keichen hat von kelt / oder die alten husten der schmire die prust damit es hilfft
¶ Für den gebrechen der matricen die da kumbt von kelt dienet diß öll wol.
¶ Platearius spracht Petroliū gesalbet auff den erkalten magen ist ser gut.
¶ Jeē das öll vertreybet alle geschwulst welche kumbt von kalter verstopffung / vñ reyniget alle faule geschwer vnd alte scheden reynniget es von grunde / welche sich verplant haben mit wasser oder mit fewer oder erfroren weren die selben scheden mit gesalbet es hilfft.
¶ Jeē für die Keilden / grinnen / zittrechten oder flechten wie man die nēnet die offt gesalbet mit Petroliū es hilfft
¶ Item es hilfft auch die / die nit wol hören / oder geschwer in den oren haben / einnen tropffen oder zwen in die oren gethan / oder mit einer dawnwol / es hilfft.
¶ Item es vertreybt den wurm vñ die darmwrinde / vnd vill ander gebrechen der menschen die von kelt kumen.
¶ Item welche gut gewant haben / es sey von Sammet Seyden oder Wüllem / oder ander war / der setz das öll in den kasten / sein gen uch vertreybt die schaben / oder ander würm.
¶ Item wer vergifft ist / oder dem vergeben wer der gebrauch ein let Petroliū in getranck es hilfft.
¶ Item welche frawen in irer geburt erkaltet wer die gepauch des öls in wein / vnd beschreich den nabel darmit /
¶ Item wen plaw flecken geschlagen oder gestossen weren / oder sunst zerfallen oder zerprochen glider hat der schmir sich mit dem öll es hilfft.
¶ Item für die grausamen plag der pestilentz gebrauch drey oder vier tropffen in wein / auch daran gerochen / vnd die peülen darmit gesalbet es hilfft.
¶ Für die Febres nim ein halbē löffel vol Petroliū mit sampt einem löffel vol salwey wasser getruncken es hilfft.
¶ Item für die wetagen der augen die do kumen von kelt.
¶ Item wer gestochen wer von einer schlangen / oder von einem andern gifftigen würm gepissen der nem des öls ein quintet vnd salbe den schaden damit es hilfft.
¶ Item wer gepissen wer von einem wütigen oder erstrecken hunde der nem des öls ein halb lot vñ schmir den schaden darmit es hilfft.
¶ Item für die spūl würm drey oder vier tropffen getruncken vnd den nabel domit geschmirt es hilfft
¶ Item für das gicht / domit geschmirt es hilfft.
¶ Item für die permuter drey oder vier tropffen eingenumen / vnd vmb den nabel damit geschmirt es hilfft.
¶ Item für den erbgrinde mit laugen rayn gewaschen vnd mit dem öll wol geschmirt es hilfft.
¶ Auch spriechen etlich es helff für den stinckenden atem / vnd für das wildt geschoß / teglichen zwen oder drey tropffen eingenumen.

¶ Diese obgeschriben gebrechen mag man alle heylen mit diesem öll spricht Platearius.
¶ Diße obgeschrieben vñ noch vil mer tugent vñ crafft hat das hochgelobte Petroleon / welche vns beschriben sein / vnnd offt bewert / durch vill Doctores in welschen vnd teütschen landen / Nemlichen durch einen hochgelobten vnd weysen Doctor Johannē von Karmona / welcher wunderliche ding zu Venedig bewert hat / zu lob dem almechtigen ewigen got / vnd zu trost vnd zu hilff allen armen gebrechlichen menschen.

Fig. 21. Early pamphlet dealing with the use of petroleum as a medicine (Printed at Nürnberg).

Platearius says that petroleum applied to a chilled stomach is very good.

Also the oil banishes all boils that result from constipation caused by cold and cleanses all festering sores; it thoroughly cleanses all wounds of long standing which arose from water or fire or were frost-bitten, if the wounds are rubbed with the oil it helps.

Similarly for scabs, scurf, mange or tetters as it is called; if rubbed frequently with petroleum, it helps. It also helps those who are hard of hearing or have a sore in the ears. If one or two drops are poured into the ears or placed in on a piece of cotton, it helps. It also gets rid of worms and strangury and many other maladies of mankind caused by the cold.

Also he who has fine garments, whether of velvet, silk or wool or other cloth; let him place the oil in his boxes; its smell drives away moths or maggots.

Also he who is poisoned or to whom poison has been given, let him take half an ounce of petroleum in his drink and it helps.

Also the woman who has caught a cold during her confinement, let her take the oil in wine and rub the navel with it.

Also anybody who has got blue bruises from being hit or knocked or has broken or crushed limbs, should rub the oil in, and it helps.

Likewise for the terrible scourge of the plague; three or four drops in wine should be used; if you smell it and rub the boils with it, it helps.

For fever half a spoonful of petroleum should be taken. If a spoonful of sage water is drunk at the same time, it helps.

Also for the days when one's eyes are sore from the cold.

Also anyone who has been bitten by a snake or bitten by some other poisonous creeping thing, should take a quintessence of the oil. If he rubs the wound with it, it helps.

Also he who is bitten by a rabid or mad dog, should take a quarter of an ounce of the oil. If he rubs the wound with it, it helps.

Also for the belly-worm. If you drink three or four drops and rub the navel with it, it helps.

Also for gout. If rubbed in, it helps.

Also for the womb. If three or four drops are taken and the navel rubbed with it, it helps.

Also for a scab of long standing. If this is washed clean with lye and well rubbed with oil, it helps. It is also to tell the truth, good for bad breath and for wind in the bowels; two or three drops should be taken daily.

The above-mentioned maladies can all be cured with this oil, according to Platearius.

The highly-praised petroleum has the above-mentioned and still more virtues and powers which have been described and often verified for us by many doctors in Romance and Germanic countries. In particular by a highly-praised and wise Doctor John of Cremona, who has verified miraculous things in Venice, to the glory of the almighty everlasting God and to the solace and help of all poor frail people."

This broadsheet, the printed area of which measures 258 × 169 mm., was probably printed by Ambrosius Huber of Nürnberg, possibly in the early

years of the sixteenth century, around 1500. Sudhoff[1] pointed out that the text of this pamphlet was borrowed largely from such handbooks as mentioned above. Comparing it with the paragraph on petroleum in the "Gart der Gesundheit"[2] of 1485 (Printed by Schoffer) we find that the entire text upto line 27 is an almost literal copy of this paragraph. The second half was probably culled from some undiscovered pharmacological handbook. The author of our pamphlet was careful to drop the introductory lines with which Johannes Platearius begins his remarks on petroleum in his Circa Instans. The latter tells us here that petroleum was found in "Greece and in certain spots on the sea-coast", but our author changes this as he has to advertise his "oil from the mountain Sibia in the land of Tussia". He proceeds in a curious fashion, ending each example of the application of the St. Catherine Oil with the words "it helps", "it cures", thus adding a Coué-like moral support to his contentions.

This pamphlet was drawn up to sell small flasks of petroleum from Modena at the larger European fairs by pedlars and was handed out to clients to give them both the moral support and instructions on how to use this oil both internally and externally. Hence the original reasonable discussion of the properties of petroleum by Dioscorides and Platearius supported by further evidence from Cassius Felix and Arab physicians in the medieval pharmacological handbooks is given here in a rather garbled form, probably by an author who had little medicine and could not consult the original sources with any profit, but who reshaped the evidence at his disposal in pharmacological handbooks in the vernacular. Hence we will find the same evidence being quoted for the St. Quirinus Oil of Tegernsee in the fourth pamphlet to be discussed.

The third of these broadsheets (Plate XIII), also entitled "The Virtue of the Noble Oil", turned up recently and is now in the hands of an American collector. This French pamphlet (see Appendix C) measures 30.5 by 18.0 cm. and was written by Charles de Minne of Antwerp, who was probably an apothecary. He mentions that he lives at the "Three Roses" in the "Old Lombard Street" and bases his claims for the virtues of the St. Catherine Oil not only on older authorities but mentions that they are recognised by many physicians in Venice, Italy, Germany and France and cites specifically the testimony of two Swiss physicians, Master Jasper and Master Alexander of Basle, both residing at Frankfort.

[1] K. Sudhoff, Zwei deutsche Reklamezettel zur Empfehlung von Arzneimitteln — Petroleum und Eichen-mistel — gedruckt um 1500 (Archiv f. Gesch. d. Med. vol. III, 1910, pp. 397-400).

[2] K. Sudhoff, Deutsche medizinische Inkunabeln (Leipzig, 1908, No. 67, p. 79).

The text runs as follows:

"The virtue of the noble oil which is most useful and beneficial for several infirmities of the body. Petroleum is an oil which (by the grace of God the Creator) oozes and drips from a rock by the effect of the sun in a strange and wonderful manner in the estate of the Duke of Ferrara near a town called Modena of Mount Sybia. It is called balsam by several people on account of its great and outstanding virtue and some people call it St. Catherine's oil. As a result of this the said mountain no longer has any snake or poisonous reptile which has now been driven out, although this region is common and favourable to these vermin. This proves the virtue of the said oil. Firstly, this oil purges and cleans any sore and heals any wound of long standing. If the oil is applied to the said wound with a feather, affixing a plaster of apostolicum twice a day.

It also gives help to those who are hard of hearing or who have some blockage of the ear; it cures one or two drops are placed in the ear with cotton.

Likewise, if a woman is pregnant and cannot give birth, she should take three drops of the said oil in her mouth and in the navel and should rub the breasts well with it; then she will give birth.

Likewise, whoever gets scalded either by fire, boiling water or tar, or is freezing because of the frost, shall rub himself twice daily with petroleum.

Likewise petroleum heals all manner of scab: first the scabs should be washed and cleansed thoroughly with hot beer, then rubbed twice daily with petroleum and all of a sudden it will cure them without causing them to grow into the body.

Likewise, whosoever has been struck, maimed or has fallen, so that the bruises and outward signs are visible, should rub them twice daily with petroleum and he will be cured.

Likewise, he who has been injured internally, either by having lifted some great weight, or has fallen, so that the inside of his body is quite mutilated or has overworked or has an internal cold, should take half of a filbert or hazel nut shell, pour a little petroleum into it, then drink it with a cup of warm beer, and then rub it on his body where the most acute pain is felt. Twice daily.

Likewise, he or she who has been bitten by a mad dog or by a snake or other poisonous creature, shall rub the wound or the bite with this petroleum and then put a plaster of apostolicum and he will certainly be cured. Petroleum is also very good for those who have cramp, gout or pains in the arms or legs or in any other part of the body. The painful spot is to be rubbed twice daily.

Those too who have cut or stabbed themselves either with a knife, bodkin, thorns or some other instruments, as a result of which some vein has been injured or if the wound is so large that it has to be stitched or bound. Such a wound must be smeared and rubbed with a feather and a drop of this oil applied and then a plaster attached; it heals in a short time.

Likewise, this petroleum is very good for pains in the eyes of less than one year's standing. It should be mixed with a little breast milk and then the eyes smeared with it night and morning.

Likewise, with this petroleum children who have broken some limb are healed. The children should be rubbed with this oil at the place where the limb is broken, then a small piece of fustian the size of a halfpenny soaked with the oil is taken and applied to the fracture and it is bound on top with a pad day and night.

Likewise, for anyone suffering from an inflammation of the bladder or from granulations; let him rub all around the private parts and the navel and he will be cured.

Likewise, this petroleum is very good for gallstones; the grounds of a stone named lapis tinta are taken and boiled in petroleum. Then it is filtered through a piece of cloth; then it is bound with a stool or splint to the penis and suddenly the stone will become broken up or smaller. But the penis must first be bathed and fomented with water in which mallow has been boiled with Daltue oil, which has often stood the test in Italy.

Likewise, for coughing or constipation of the stomach resulting from the cold; rub the chest with this petroleum, then drink an eighth of an ounce of this petroleum which is a good cure for man.

Likewise, this oil is more effective in the cold regions for fat people of cold humour than in the hot regions for lean people of cold humour.

Petroleum has all these virtues and several others not mentioned here, which have often been applied by many learned doctors of medicine of Venice as wel as of Italy, Germany and the Kingdom of France, chiefly in the town of Frankfurt, by two expert doctors of medicine, namely Master Jaspar and Master Alexander of Basel, living in Frankfurt.

If anyone, whether apothecary or doctor, has found the above-mentioned oil is other than good and that it does not come from Modena, he ought to forfeit the liberty of his person and have his chattels confiscated.

By me, Master Charles de Minne, living in the renowned city of Antwerp near the poultry market, in the old Lombard Street, bearing the three roses."

Here again about one third of the broadsheet is taken up by a woodcut illustrating the seepage of Monte Zibio near Modena, the men skimming the waters for the oil and the wild animals drinking from the brook (Fig. 19). The most remarkable feature of this picture is not the sweating rock or the collection of oil but the demonstration of the means of transporting the oil. We see the oil shipped in bottles very similar to the large size hip-flasks of pottery, glass and metal still common in South European countries. They seem to have been the proto-type of our standard packing, the jerry-can, and they are shown carried on the back of peddlars, on the saddles of pack-horses and camels and even stowed into four-wheeled carts. We wonder whether any examples of such cans could still be found in our museums where they may have lain unnoticed for centuries, as their use was not known until this broadsheet was published. This pamphlet is said to have been printed between 1540 and 1550 and it is therefore the youngest of the series.

This survey of the oldest known broadsheets on petroleum shows that the authorities of Modena, either the Duke of Ferrara or his representative, the "captain of the mountain", made good use of the possibilities of the printed pamphlet to increase the sale of their oil in Germany and France. So far only one type of such a pamphlet has turned up which is devoted to the St.

Quirinus oil of Tegernsee, which source of supply must have found the Italians active and dangerous competitors. The text of the Antwerp pamphlet, which does not cite the early medieval and classical authorities, but which is more business-like, may go back to some extract of the pamphlet written on the Modena oil by doctor Francis Ariosto (chapter VII) in 1460, though this essay itself was not printed until 1690. The latter was certainly a more scientific document and a true precursor of the report on the Gabian oil from Montpellier which we quoted in Chapter I.

The oldest known broadsheet on the Tegernsee petroleum is entitled "Ursprung, Wirkung und Gebrauch des sogenannten heiligen Quirin-oeles, welches bei Kloster Tegernsee in Oberbayern aus der Erde hervorflieszt" (Origin, efficacy and use of the so-called holy Quirinus-oil, which oozes forth from the earth near the monastery of Tegernsee in Upper-Bavaria) (Appendix D). This broadsheet shows Saint Quirinus in front of the lake and the monastery. A special prayer forms the introduction of the broadsheet which gives many details of miraculous cures effected by the oil of St. Quirinus. One of the monks of Tegernsee composed a poem in Latin in praise of this oil. The broadsheet (18.5 × 29 cm.) was printed by the monastery press, it now forms part of the Bayerische Hof- und Staatsbibliothek, where the other rich possessions of the monastery library are also kept (Einblattdruck VII 24^{sha}; formerly 2° Bavar. 1400 VII, 36).

The copy (very similar to that illustrated in Plate XIV) dates back to the XVIIIth century, but we do not know when it was first printed. There seems to have been a constant demand for this broadsheet. When the monastery was secularized the matter was still ready for use in the Tegernsee printing office and the official in charge of the secularisation had it thrown into the lake, as Johann Chr. Freiherr von Aretin tells us in his "Beiträgen zur Geschichte und Literatur" (1803, vol. I, Heft 2, page 73). The text of this broadsheet is reproduced in Appendix D. We have not translated it as it differs little from the less well-known companion broadsheet entitled "Krafft, Tugend und Würckung des Oels Sancti Quirini zu Tegernsee" (Potency, virtue and efficacy of the Saint Quirinus oil of Tegernsee) which measures 16 by 29 cm. and which is also in the Bayerische Staatsbibliothek at Munich (Einblattdruck VII, 24^{sh}). It dates back to the XVIIIth century too.

The text of this second Tegernsee broadsheet (see Appendix E) runs as follows:

"This oil is warm and dry, hence it penetrates, dissolves and consumes:
For headache, shooting pains, dizziness, delirium and epilepsy if not merely 3, 4 or 5 drops are taken in wine or other beverage but applied to the nose, temples and pulse, it invigorates the brain and has proved itself over and over again.

For discharge from the eyes and cataract and applied with a little feather rendered to people sightless in some other way it consumes the cataract skin and restores sight, which has been of help in many cases. Anybody who has running from the ears or blockage should let two or three drops fall into the good ear stop it with a piece of cotton and lie on the bad ear, and it will escape through the latter.

For toothache, cover the gum inside with a piece of cotton dipped in it.

For wheezing that comes from cold also for a cough of long standing, rub the chest with it.

Anybody who has suppuritive fever whose lungs and liver are diseased, should take 30 drops of it in wine, mead or some other beverage.

It also warms the stomach and makes it well-disposed for digestion, applied externally.

For colic take 40 or 50 drops in warm wine, also tie a piece of cotton with some warm drops over the navel and rub the lower part of the body with it.

Anybody with jaundice, as anyone with dysentery, should take some drops of it.

Taken in milk or wine, it banishes tapeworm in young and old.

For strangury, gravel, stone and pains in the hip take 20 or more drops in wine, as well as rubbing the genitals, loins and small of the back.

For the pressing-up of the womb apply the vapour of this oil to the nose and lower parts of the body and rub the navel with it.

Item if women cannot get rid of the placenta, take 12 to 20 drops in warm wine.

In times of infection, contagion plague and pestilence if 1 or 2 drops of it are taken early in the morning on an empty stomach, it prevents this disease, and persons who have already had such diseases should drink 30 drops in wine and rub it on.

For gout, syphilis, spasms, scabies, scurvy, spots on the body or face, weakness of the limbs, chill, disease of the limbs, apply warm repeatedly.

It is also good for all swellings, open, poisoned and worm-eaten sores on people and cattle, rubbed on and poured in.

Any horse that has the tapeworm should be given a little glassful.

It always banishes the moths and cockroaches when letters and clothes are kept in chests.

Anybody who rubs his hand with this oil with ground saffron in it, may catch and attack all manner of poisonous adders, lizards and slowworms safely and without harm."

When we compare the contents of these broadsheets with those on the Modena oil we find that they differ very little. However, the authors of the Tegernsee pamphlets have not mentioned the ancient medical authorities which abound in the other three. The publicity of the Modena authorities proved more effective and Modena oil was imported into many European countries. The production of Tegernsee never reached the level of that of the wells near Modena.

Gradually knowledge of such natural products as petroleum and bitumen increased and their alleged medicinal properties became the object of proper medical and scientific research. Aloysius Mundella, a physician of Brescia and Padua recognized that the Arabs had added many medic-

aments such as "mummy" (reputed to be a kind of bitumen) to the lists of Galen and other classical authors. He decried the use of the "abominable and detestable Mumia" [1] which his contemporary Antionius Musa Brasavola, physician to pope Paul III after teaching at Ferrara, had shown to be the remains of an embalmed corpse. Mundella agreed with the German herbalist Leonhard Fuchs that it was much better to use bitumen or petroleum, both pure natural products, instead of this mumia. A famous physician like Bernard Ramazzini (1633-1714), [2] who was a professor of medicine at Modena and later at Padua edited Ariosto's essay on the Modena oil and carefully discusses the twenty detailed cases where according to Ariosto the oil brought relief or healed the patient. He himself uses petroleum as a purgative and applies it to skin-diseases and burns.

His contemporary, Paul Boccone, had a lively correspondence with scientists and nature lovers all over Italy. He published these letters together with comments of his own. [3] In this book he frequently speculates on the origin of petroleum and bituminous substances which he knows to contain a high percentage of "sulphurous principle" and "oily earth" (terra pinguis). Subterraneous fires distill such earth and form petroleum with its characteristic gases, sulphurous fumes. He holds it to be closely related to amber and fossil resins, which theory he also bases on the closely related medicinal properties of "karabé" (oil distilled from amber or resin) and of "juniper oil" (prepared from juniper berries by destillatio per descensum) due to the fact that they all contain the "sulphurous principle". Naphta, petroleo or "olio di Sasso" (as he sometimes calls it) when applied externally protects the skin, like it does timber when painted with oil, it cleans the skin and taken internally not only cleans the intestines but dissolves obstructions in the human body.

Of course Boccone waxes lyrical about the medicinal properties of the many Italian crudes and bitumens notably about the oil of Modena. However, he also mentions some other oils which are either imported types of petroleum or oils which due to their nature have similar properties. Thus he mentions "balsamum Tegernseense Bavaricum", the balm from Bavarian Tegernsee which medicine, bearing the seal of St. Quirinus, comes "from a mountain of Saxony"! There is also the "liquid amber of the New World called Tacamahacae", which is a kind of "liquid Peruvian resin", probably our Peruvian balsem. The third is "miniac tennah (minyak tanah: oil from the earth), a

[1] A. Mundella, Annotations (Basel, 1538, p. 639). — A. Brasavola, Examen omnium simplicium medicamentorum quorum in officinis usus est (A. Blada de Asula, Rome, 1537, pp. 453-455, 459).

[2] Bernard. Ramazzini, Opera Medica (curavit J. Radius, Leopold Voss, Leipzig, 1828, vol. II, pp. 829-852).

[3] Paolo S. Boccone, Museo di Fisica (Venezia, 1697, pp. 32-38, 170-174).

balm from Sumatra in the East Indies, which Libavius called mineral liquid amber and we balm of Sumatra". He adds that "this Olio de Sasso (both white and black) is brought from New Batavia by Dutch merchants to Holland together with many aromatic products of the East and thence even imported into Italy". This information is the more remarkable as the earliest report on the seepages of Sumatra is given by Van Linschoten [1] in 1596 and not earlier than 1636 was an order issued to the representatives of the Dutch East India Company at the Sultan of Atchin's court [2] to collect a few pots of this "oil from the earth" (oly van aarde) for the benefit of the Members of Council, who "esteemed it highly and used it with great benefit for their stiff limbs". [3] Hence within a generation this imported oil from the Dutch East Indies had acquired a place on the drug markets of Europe, even in Italy, where the oil of Modena had a reputation founded on at least 250 years of experience.

Other substitutes mentioned by Boccone are "balm of musk", hailing from America, "Samatramum balsamum" from St. Lawrence Island, a "noble resin", "waxy balm from Wallachia" (probably Galician ozokerite), "balm of bergamot" and "balsamum fossile Suchalotiamum" from Moravia.

The marvelous properties of petroleum mentioned in the old broadsheets is repeated by many later medical and general encyclopaedia. We find it in Valentini's handbook, [4] in Blancard's lexicon [5] and in the encyclopaedia of Krünitz [6] and Zedler. [7] Both these authors mention that petroleum being of a "fiery nature" is mostly applied only in folk medicine or only by veterinary surgeons. However, it maintained its reputation in many a later book and the excellent advertizing of the Modena oil still finds its reward in the "Petra Oleum Italicum" recommended in German medical handbooks in the later half of the nineteenth century for skin diseases.

Petroleum is also mentioned in many pharmacopoeia in early centuries. Thus we find the following entry in a famous Dutch handbook, [8] a translation of a German handbook written by Christ. Wirtsung:

[1] Jan Huygen van Linschoten, Itinerario . . . near Oost- ofte Portugaels Indian (Amsterdam, 1596, fol. 25).

[2] Dagregister van den Opperkoopman I. Compostel, November 9, 1636.

[3] Generale Missive of December 22, 1643.

[4] Valentini, Natur- und Materialienkammer (Francfort a. Main, 1704, p. 32, cap. XI: "Von dem Judenleim, Stein- und Erdöl").

[5] Stephen Blancard, Lexicon medicum renovatum (Leiden, 1717).

[6] Krünitz, Oekonomisch-technologische Encyklopädie (Berlin, 1806, part 104, p. 633, article Oel).

[7] Zedler, Universallexikon (Leipzig and Halle, 1744, vol. 39).

[8] Carolus van Battum, Medicijnboeck . . . (transl. from the German, Amsterdam, 1627).

La vertu de la noble huyle / laquelle est tresvtile et prouffitable pour pluseurs infirmite; du corp;.

Petreolum est vne huyle / qui (par la grace de Dieu le createur) sort et degoutte dune roche par operation du soleil / en estrange et abominable maniere es regiõs du Duc de Ferrare aupres dune ville appellee Modene de la montaine Sybia. Laquelle est appellee Tausme de pluseurs gens par la grande et singuliere vertu et bonte quelle est cy nommee huyle de vnte Katherine / au moien de laquelle ne demeure aulcune couleuvre ou telle venemeuse als dicte montaigne que ne decha[illegible] tout / combien que la region soit commune et enclime a telle vermine. Laquelle vertu de la predicte huyle sensuyt.

Premierement ceste huyle purge et nettoye toute vlceratiõ guerissant toute ancienne vlcere / Si on oingt icelle playe de la dicte huyle de vne plume / y appolant deux fois le iour vne emplastre de Apostolicum.

Item elle donne secours a ceulx qui sont ours de corps / ou qui ont quelque apostumation es aureilles / en posant vne goutte en deux avec du cotton en laureille elle guerit.

Item vne femme encepte denfant / si elle ne peut enfanter / elle prendra trois goutes de celle huyle en la bouche / et en mombra et sains bien frottes de ladicte Petrolle puis elle enfantera.

Item quiconque sera eschaulde soit par feu eaue bouillant / ou poix / on sera mal sonde de geller / il se frottera deux fois le iour de ceste Petrolle.

Item ceste Petrolle guerist toutes maniere de rongne / premierement on lauera et nettoiera trebien les rongnes de biere chaulde / puis on le frottera deux fois le iour de Petrolle / et soubain elle guarira sans faire rentrer les dictes rongnes.

Item quiconque sera frappe ou mutile / ou tombe / de sorte que on en boit les perfumes et apparens / quil le frotte deux fois le iour de Petrolle et il se trouvera guarry.

Item quiconque sera blece interieurement / soit par auoir soulene quelque grande poix / ou soit quil soit cheut / de sorte quil soit tout mutile par dedens le corps / ou quil ait trop travaille / ou soit refroidie / il prendra la demy q pourra entrer en la demie coquille dune auelaine ou noisette de ceste Petrolle / et puis le boire auecq vng goblet de biere chaulde / et puis le frottera sur le corps la ou il sentira la plus grande douleur deux fois le iour.

Item celuy ou celle quy sera mord dung chien rabbi / ou bien picque de vne couleuvre / ou autre venemeuse beste / frotera la plaie ou morsure de ceste Petrolle / et puis y mettra et posera vne emplastre de apostolicum / et soubdainement il guarira.

Petrolle est aussy moult bonne a ceulx quy ont cramp / goutes / ou paine et douleur que lhomme peut auoir es bras / et iambes ou en quelque endroit du corps / on se frottera sur la douleur deux fois le iour.

Ceulx aussy quy se seront trenche ou perche / soit de couteau / poinçon espinnes ou quelque autre instrument / mesmement que quelque veine ne soit blessee / ou que la plaie ne soit si grande quil la conuenne coudre ou rattacher il conuient oingdre et frotter telle plaie auec vne plume et faire degoutter vne goutte de telle huyle / puis y appoiser vne emplastre / elle guerist en brief temps.

Item ceste Petrolle est moult bonne pour douleur des peulx / quy ne encore dure an; an / laquelle on mettra auecq vng peu de laict de femme puis en oingdre les peulx soir et matin.

Item de ceste Petrolle on guarist enfants; derompus / assauoir on oindra les enfants; de ceste huyle au lieu ou ilz sont derompus puis on prendra vne petitte pieche de fustenne de la grandeur de vng double patart laquelle on mouillera de ceste huyle et puis on le posera sur le lieu derompu / le liant dessus auecq vng coussinet de iour et du soir.

Item pour celuy quy aura la chaulde pisse / ou grauelle il frottera ses parties honteuses tout alentour et aussy le nombril / et se trouuera guary. Item ceste Petrolle est moult bonne encontre la pierre / on prendra poudre de vne pierre nomme lapis lincis laquelle on bouillera en Petrolle / puis on le passera par vng drappeau / puis on lescurera dune seringue ou escurre au membre virril / et soubain la pierre se briserа ou diminuera. Mais le membre virril doibt premierement estre baigne et estuue deaue en laquelle sera boullu mallue auecq huyle Dolliue / che souuent a este esprouue es Italies.

Item contre tour ou estoupement destomach procedant de froidt / oignez la poictrine de ceste Petrolle / puis beuuez la huictiesme partie de vne once de ceste Petrolle et aide mouli a la personne.

Item contre enflure de la matrice dune femme on prendra vng charbon ardant / dedens vng pot ou telle de terre / puis espandez de ceste huyle dessus puis vous estuuez dessus et telle odeur est fort aidable.

Item la femme quy est oppressee de la matrice / faicte vng petit peloton de cotton puis le mouillerez de Petrolle / puis lenfermerez au petit ventre / et soubain que la matrice aura receupt odeur de la Petrolle / elle se trouuera allegee / che que souuent a este experimente en Italie. Item ceste huyle est plus conuenables es froides regions / e aux gents gras de froide nature / que non aux regions chaudes ou gents maigre de froide complection

Ceste Petrolle a toutes ces vertus et encoire pluseurs autres qui ne sont pas icy mẽtionnees / lesquelles ont este fort souuent approuuees par moult scauants docteurs en Medecine / tant de Grenise comme Dytalie / Allemaigne et royaulme de France / e principallement en la ville de Francquefort de deux experts docteurs en Medecine / nõmes maistre Wailie Jaspar et Maistre alexandre / den Basel / residents audict Francquefort.

Sy quelqun (soit Apoticaire ou Medecin) se trouue ceste huyle predicte autre que bonne / et autre quelle dient de la Vache le vueil perdre et fourfaire corps et biens.

Par moy Maistre Charles de Minne demourant en larrenommee ville Danuers / ces le marche aux poulets / en la vieille rue du Lombardt / tenant les trois Roies.

Krafft / Tugend / und Würckung deß Oels Sancti Quirini zu Tegernsee.

Geber zu dem Heiligen König und Martyrer QVIRINVM.

HOch-Heiliger Martyrer / und Auserwölter Freund Gottes Quirine / ich bitte Dich auß demüthigem Hertzen / erwerbe mir bey Gott durch dein heilige Vorbitt / daß Er mir durch den Gebrauch diſes heylſamen Oels verleihen wolle mein zuvor gehabte Gesundheit / Wohlfart der Seelen / Verzeihung / und Vergebung meiner Sünden / ein seeliges Sterbstündlein / und nach diſem zergänglichen Leben die ewige Freud und Seeligkeit: Durch JEſum Christum / der mit dem Vatter und Heiligē Geiſt gleicher GOtt lebt / und regiert von Ewigkeit zu Ewigkeit / Amen.

DIeſes Oel iſt warm / und trucken / dahero es durchtringt / reſolvirt / und verzehret:

Wider das Hauptwehe / Haubtgeſchoß / Haubthür / Tob- und fallende Sucht nicht allein 3. 4. oder 5. Tropffen in Wein / oder anderen Getränck eingenommen / ſondern auch in die Naſen / Schläff / und Pulß angeſtrichen / ſtärcket das Hirn / iſt vilmahls bewährt worden.

Wider die Flüß / und Vberfell der Augen / auch ſonſt erblindten / mit einem Federlein eingeſtrichen / verzehret daß Fell / und wiederbringet daß Geſicht / welches auch vielmahls geholffen.

Welcher Flüß / und andere Verſtopffung deß Gehörs hat / der laſſe ihme zwey oder drey Tropffen in das geſunde Ohr fallen / mit einer Baumwoll verſtopfft / und auf das gehörloſe Ohr gelegt / ſo fahret es durch daſſelbe hinaus.

Wider daß ſchmertzliche Zahnwehe inwendig daß Zahnfleiſch mit einer darein getunckten Baumwoll bedeckt.

Wider daß Kheichen / ſo von Kälte herkommt / auch alter Huſten / die Bruſt damit geſalbet.

Welcher die Aitersucht hat / deme auch Lungen und Leber faulet / ſolle deſſen 30. Tropffen in Wein / Meth / oder andern Getranck einnehmen.

Es erwärmet auch den Magen / machet ihn wohlgeſchickt zum verdähen / ſelbigen von auſſen geſalbet.

Wider das Grimmen in einem warmen Wein 40. oder 50. Tropffen eingenommen / auch über den Nabel etlich warme Tropffen in Baumwoll übergebunden / und den untern Leib warm damit geſchmieret.

Welcher mit der Gelbſucht / wie auch der rothen Ruhr behafft / der nehme von ſolchem etlich Tropffen ein.

In Milch / oder Wein eingenommen / vertreibt die Würm in dem Leib bey Jung und Alten.

Wider die Harnwinde / Grieß / Stein / und Lendenwehe ſowol 20. oder mehr Tropffen in Wein eingenommen / als auch ober den Gemächten / Lenden / und Creutz / warm damit geſchmiert.

Wider das auffſtoſſen der Gebährmutter / den Rauch von dieſem Oel in die Naſen und untern Leib eingelaſſen / auch den Nabel damit geſchmiert.

Item ſo [illegible]rauen von der Nachgeburt nicht können ledig werden / von 12. biß in 20. Tropffen in warmen Wein eingenommen.

In vergifften / contagioſen / als Petechen / und Peſtilenz-Zeiten / frühe nüchtern 1. oder 2. Tropffen davon eingenommen / verhindert dieſe Kranckheit / und ſo etwan die Perſonen ſchon ſolche Zeichen hätten / bey 30. Tropffen in Wein getruncken / und darauf geſalbet.

In dem Podagra / Frantzoſen / Zitrachen / Räudig- und Grindigkeit / Flecken an dem Leib / oder Antlitz / Schwachheit der Glieder / erfrört / Gliedſucht / offt warm angeſtrichen.

Es iſt auch gut wider alle Geſchwulſt / alte löchrigte / faule vnd wurmige Schäden an Menſchen / und Vieh / mit dieſem geſchmiert / und darein gegoſſen.

Welches Roß den Wurm hat / dem ſoll man ein kleines Bläter-Gläßlein voll eingeben.

Bey Brieffen und Kleidern in den Truhen aufbehalten / vertreibet allda die Müben und Schaben.

Wer die Händ mit dieſem Oel / darin Gaffran zerrieben / ſchmiert / darff ſicher und ohne Schaden allerley giftige Nattern / Eydexen / und Moll-Würm fangen und angreiffen.

The Tegernsee pamphlet (XVIIIth cy.) (Photo Bayerische Staatsbibliothek, Munich).

"*Petrolye*, Greek: naphta, or naphtas (Plutarch); petrelaeon (Nicolas Myrepsus); pharmacon (Suidas); Latin: bitumen liquidum, bituminis colamentum; and in the Apothecary's shop petroleum and oleum petre. There are two species. First the white which is imported here from Naples and from Italy. The black type we find abundantly in many German sites notable in the region of Wietze, half a mile from Werde, in the mountains between Hagenau and Weissenburg, near the village called Lampertsloch. There we find a fountain in a valley which yields such a quantity of this oil during the months of April and May, that all the people that can congregate collect sufficient oil from it to replenish their lamps during the entire winter and also to lubricate their carts.

Quacks and other rogues also collect bottles full of this oil and sell it in foreign countries, pretending they have obtained it in far-away lands at great risks, who know little medicine and heed such science little but prognosticate from the stars in the sky in order to prophecy the good people marvelous things for the future."

Evidently van Battum has come to doubt the many unreasonable claims made in the pamphlets extolling the virtues of petroleum. Some of these pamphlets were not issued by the great exporting centres but were composed locally by the chemists who imported the famous crudes, such as the Frenchman Roque Foura whom Pomet [1] mentions and who seems to have written several such pamphlets himself to promote the sale of the imported Italian petroleum. As a matter of fact their contents are even more phantastic than the original ones.

When the chevalier de Jaucourt wrote his article on "pétrol" for the famous Encyclopédie of Diderot and d'Alembert [2] he also shared van Battum's doubts for this was what he wrote on the medicinal properties of petroleum:

"Dioscorides thought highly of the naphtha of Babylon as a remedy for several ailments. He attributes to it a great number of very important medicinal virtues which nevertheless have no interest for us since this "petroleum" is no longer known to us. Besides, one can hardly be favourably predisposed to the opinion of Dioscorides when it is seen that he praises the naphtha of Babylon to the point of putting it on the eyes to dispel inflammation and white spots (leucoma).

The Italians are in a stronger position to consider their "petrols" as a highly penetrating, incisive and balsamic remedy suitable with some chronic ailments, and still more used externally to strengthen the nerves and enfeebled parts and impart movement and resilience to relaxed fibres. In the latter case, the petroleum of Gabian may in the Languedoc be substituted for it. I know all the praise that Koenig, Ettmuller, Schroeder, Boecler and some other German writers accord to petroleum oil: I know how they sing its praises in the suppression of menstruation, hysteria, quartan fever, toothache, worms, renal pains, etc.—but I know also that such prescriptions are very like those of old wives or of society people who discuss matters

[1] Piërre Pomet, Histoire Générale des Drogues (Loyson et Pillon, Paris, 1694, Pars III, lib. iii, cap. xvi).

[2] Chevalier de Jaucourt, *Pétrol* (Encyclopédie ou Dictionnaire raisonné des Sciences, Arts et des Métiers, (Vol. XII, 1765, p. 473).

medical without having the slightest idea of what they are talking about, since all these ailments arise from different causes and require perforce diverse remedies opposite to the causes of the evil! In the very cases in which petroleum oil might be suitable we have much better remedies to use. Moreover, it must be admitted that if one were to rely on a few true observations of the virtues of petroleum that could only be as a result of experiments repeated by capable doctors on the inhabitants of the countries which produce this bituminous fluid; I mean the Duchy of Modena or Placentia. Anywhere else petroleum oil can hardly be prescribed with confidence as to its effects. This oil loses all its subtle virtue through transport. Our chemists and druggists never have any of the stuff pure because it is sent to them adulterated at the very sources. I am not speaking of the other adulterations retailers make to it.

Let us conclude that we must dispense with the oil of petroleum as far as medecine is concerned without regret, and conjure ourselves to its uses for some techniques and to speculative consideration of its origin and of the special qualities which distinguish it from all vegetable and artificial oils."

However, as late as 1839 we find Prof. Fournel citing ancient authorities on the use of petroleum for scabies,[1] the ancient belief in authorities still being rampant. Hence all during the fifteenth, sixteenth, seventeenth and eighteenth centuries the ancient classical and Arab traditions on the healing powers of petroleum were accepted as gospel truth by the public and they formed the substance of the text of many broadsheets proclaiming the virtues of the petroleum from this or that seepage. Not until later in the eighteenth century did actual critical observation and research enter this field to dispell many of the older contentions on the healing power of oil, though even in the middle of the nineteenth century the sale of Kier's Rock Oil still played an important part in the rise of the modern American petroleum industry.

[1] M. Fournel, Emploi chez les anciens de l'huile du pétrole dans le traitement de la gale (C. R. Acad. Sciences vol. IX, 1839, p. 217). — T. Healde, The Use of Oleum Asphalti in Ulcers of the Intestines, Lungs and Viscera (London, 1769).

APPENDIX A

TEXT OF THE GENEVA PAMPHLET (1480)

A tous ceulx que ces presentes lettres verront Salut sçauoir faysons Comme moy Guyllaume Grangier Licencié en loix Notaire apostolique et secretayre de monsigneur le Duc de Ferrare certifié par le commandement de mondict seigneur duc de Ferrare que ceste huylle nommée Petroleon laquelle sourt dune Montagne ou Roche par la voulenté de dieu et nostre dame. Laquelle montagne se nomme Montesible assise à cinq journées de Romme. Laquelle huylle mondict seigneur de Ferrare a fait experimenter par plusieurs grans docteurs en medicine tant de Romme comme de Naples et de Bouloigne lequels medecins on trouvee ladicte huylle fort utile et proffitable contre les maladies froides que peuvent venir aux corps humains. Ainsi comme il apparait par les articles cy après ensuyuant faictes et composees par les dicts docteurs affin de demonstrer les grans et nobles vertus et propriétés de la dicte huylle.

Et premierment dict Auicenne au second livre de son Canon ou propre chappitre de Petroleo que ceste huylle est chaulde et seiche iusques au quart degré et est subtile résolutive apperitive des oppilations et estoupements du corps dont viennent souvent grans maladies. Elle est moult proffitable à la douleur des hanches nommé seraticque et à toutes douleurs de ioinctures quant elle vient de cause froide quant on en frotte les hanches et aultres lieux malades devant le feu au soir et au matin.

Pareillement la dicte huylle vault aux douleurs et sourdesse des oreilles mais quils ne soient sourds de nature procedans de cause froide en mettant dicelle huylle deux ou trois gouttes dedans les oreilles et ung peu de coton au soir quant on se va coucher.

Item ceste huylle vault a la taye des yeulx et à leaue qui descend aux yeulx en distillant ung petit dedans loeil et puis mettre ung petit drappeau de linge mouillé en eaue posé comme dessus.

Item elle vault contre une maladie du poulmon nommee Asmetique passion c'est à dire deffault ou difficulté dalaine et à la toux ancienne en prenant une dragme de ceste huylle avec deulx onces de eaue de ysope tiede.

Item elle appaise les douleurs du ventre comme colique passion, yalicques tortions des bouyaulx et aultres senbables douleurs.

Item boire une dragme de ceste huylle consumme et de gaste les ventosités de la vessie et oste la froidure de la matrice aux dames et par ainsi les dispose à conception, mais il en est de deux manières cest assavoir de la blanche et de la noire dont la blance est la meilleur comme cestecy.

Item dicelle dist Mesué lèvangeliste des medecins que les anciens philosophes sont convenus par rayson et experience que ceste huylle a des operations secretes et lappellent oleum secretorum invamentorum. Les aultres appellent huylle divin les aultres huylle de sapience les aultres huylle benedicte les aultres huylle saincte et tous ces noms procedent des grans propriétés et vertus quelle a et est ceste huylle naturelle de laquelle est à propos et est trouvee es lieux sulphurieulx et es resudes dune pierre pour laquelle cause est appellee Petroleon et est engendree quant la gresse de la terre et de leaue par actions de chaleur est convertie en parties resudes et ceste huylle selon le dict docteur a vertus calefactive resolutive penetrative consummative des superfluités.

Item elle est bonne a Epilence que on appelle le mal sainct Jehan en frottant la nucque au soir et au matin et en prenant une dragme au matin avecques deux onces deane de saulge.

Item elle vault a Paralisie en frotant la nucque dicelle chaulde et les parties blessées.

Item elle vault aux gens oblyeux ou ayant faulte de mémoire par habondance de flumes en usant dicelle comme dessus.

Item elle vault à la douleur de la rate, des rains et de la vessie de la matrice des ioinctures du dos et des genoulx et gouttes froides des pieds des yeulx quant procedent de froid en frotant les dictz lieux dicelle chaulde au soir et au matin et en beuvant dicelle comme dict est.

Item dicelle dist Serapion à son serviteur quelle a les propriétés dessusdictes et dist quelle est des grans secrets des philosophes.

Item elle vault à rongnes dartres et a playes faictes de cousteaulx elle incarne et consolide les dictes playes.

Item appert que cestuy huylle a vertus contre maladies procedans des causes froides car si vous prenez quattre gouttes dicelle et les mettez dedans ung voyrre de eaue froide et alume le dicte lieu et elle ardra. Parquoy appert quelle est très chaulde et puissante.

Item elle vault et est bonne contre toute morsure de beste venimeuse prenez de ladicte huylle et la mixtionnez avecques du vinaigre et les faictes boulir ensemble et en frotez la playe elle tyrera dehors et garde denfler ladicte playe.

Item plus dict Plataire Ecassius (sic) felix en son Circa instans our chappittre de Petroleo ensemble toutes les vertus devantdictes que cest ung souverain remeyde contre la pierre quant vous prendrez de la pouldre de la pierre qui

se nomme Lapis lincis que vous trouverés chiefs les apoticaires et les boullir un peu ensemble et puys le gecter par la verge en la vessie avec une seringue elle rompt et degaste la pierre combien quelle est dure grosse et confermee. Mais avant cela on doibt estuver deux ou trois jours le lieu autour de la verge deaue de coction de malves avec huylle dolive pour remolir la pierre et eslargir et ouvrir les voyes et conduicts de la vessie et de la verge par là où la pierre debvra passer. Et si on ne trouvoit poinct de ladicte pouldre on pourroit prendre quelque chose convenant au cas en reprimant ung peu la chaleur de la dicte huylle comme est eaue darcacange ou autres semblables.

Item est à noter que quant vous prendrez de ceste huylle on la doibt prendre avec quelque eaue froide et moite comme eaue de Cicorée buglose ou eaue de Cherfeuil et semblables.

Item elle vault et est bonne contre toutes douleurs de dents quant on prend de la dicte huylle chaulde et en frotez la joe en prenant ung peu de coton et le boutez dedans la dicte huylle chaulde et le boutez sur la dent qui faict mal.

Item la dicte huylle vault contre la fieuvre qui est dedans le corps de la personne quant on prend une dragme avecques deux onces deaue dandive ou dysope quant la fieuvre veult prandre en boyre et frotez lestomac et les rains de ladicte huylle chaulde toute pure.

Item elle vault contre la douleur du stomach quant la personne se send enfroidie ou reprins et plain tellement quil na point dapetit de manger prenez de ladicte huylle et en frottez la poictrine dicelle chaulde le soir quant vous irés coucher et vous vos trouverez bien le landemain.

Item elle vault et est tresbonne allencontre les vers des enfans et de toutes gens en se frottant le crottet de la poictrine avec ladicte huylle chaulde.

Item les choses dessus escriptes sont véritables et esprouvees par la forme et manière que dessus est dict.

En tesmoing de Nicolas basset Capitaine de ladicte montaigne Messire Francoys arioste docteur en medecine de la cité de Ferrare et missire Jehan vailam docteur en loix et conseillier dudict seigneur de Ferrare et moy Guilliaume Grangier ay signé ces presentes par le commandement de mondit seigneur. Le sixieme jour du moys de May. Lan Mil quatre Cens quatre vingts. Donné par copie extraict du propre original.

Laus deo. Amen

APPENDIX B

TEXT OF THE NURNBERG PAMPHLET (1500)

Die tugent des edelen Öles, welches man gebrauchet fur vil gebrechen des leybes.

Petroliū ist ein öll, das von den gnaden gottes schwitzet ausz einem steinem pergk. durch wurckūg der sunnen. in dem landt Tussia. auff einē hohen perg genāt Sibia. vñ ist nicht gemacht als essliche sprechē. darumb wirt es durch seiner grossen tugēt willen von vil lewtten Balsam genāt: auch wirt es genant sant Katherinen ol: darūb pleibt keyn gifftiger wurm noch Schlange an dem perge. welches gewurbme in den landen ser gemeyn sein. Diesz haylsamē oles tugent hie beschriben sindt vertreybet.

Cassius felix. Auicenna sprechen das Petroliū sey heyss vñ trucken biss an den viertten grad.

Item sein tugent ist auflösen vnd zu im ziehen vnd verzeren die materj die von kelt kumbt.

Item fur den krampff vnd Reissen Zittern oder Schwinden der glider / als mit dem öll geschmirt es hilfft. spricht Auicenna in libro Pentectorū.

Item es dient auch fur den wetagen der füsen genant Podegron oder ziperla.

Item für die wetagen der lend / vnd wider die kalt sucht / vnd derm gegicht darmit geschmirt.

Fur den steyn ist es die aller best ertzney die lenden vnd ob dem gemecht damit geschmirt / spricht Platearius.

Wer das keichen hat von kelt / oder die alten husten der schmire die prust damit es hilfft.

Fur den gebrechen der matricen die da kumbt von kelt dienet diss öll woll.

Platearius spricht Petroliū gesalbet auff den erkalten magen ist ser gut.

Itē das öll vertreybet alle geschwulst welche kumbt von kalter verstopffung / vñ reyniget alle faule geschwer vnd alte scheden reynniget es von grundt / welche sich verprant haben mit wasser oder mit fewer oder erfroren weren die selben scheden mit gesalbet es hilfft.

Itē für die Reüden / grimen / zittrechten oder flechten wie man die nēnet die offt gesalbet mit Petroliū es hilfft.

Item es hilfft auch die / die nit wol hören / oder geschwer in den oren haben / einnen tropffen oder zwen in die oren gethan / oder mit einer pawmwol / es hilfft.

Item es vertreybt den wurm vñ die harmwindt / vnd vill ander gebrechen der menschen die von kelt kumen.

Item welche gut gewant haben / es sey von Samet Seyden oder Wüllenn / oder ander war / der sess das öll in den kasten / sein geruch vertreybt die schaben / oder ander würm.

Item wer vergifft ist / oder dem vergeben wer der gebrauch ain lot Petroliū in getranck es hilfft.

Item welche fraw in irer gepurt erkaltetw er die geprauch des öls in wein / vnd beschreich den nabel dazmit.

Item wen plaw flecken geschlagen oder gestossen weren / oder sunst zerfallen oder zerprochen glider hat der schmir sich mit dem öll es hilfft.

Item fur die grausamen plag der pestilenz gebrauch drey oder vier tropffen in wein / auch daran gerochen / vnd die peülen darmit gesalbet es hilfft.

Fur die febres nim ein halbē löffel vol Petroliū mit sampt einem löffel vol salwey wasser getrunckē es hilfft.

Item fur die wetagen der augen die do kumen von kelt.

Item wer gestochen wer von einer schlangen / oder von einem andern gifftigen wūrm gepissen der nem des ölls ein quintet vnd salbe den schaden damist es hilfft.

Item wer gepissen wer von einem wüttigen oder töretthen hundt der nem des öls ein halb lot vñ schmir den schaden darmit es hilfft.

Item fur die spūl wūrm drey oder vier tropffen getruncken vnd den nabel domit geschmirt es hilfft.

Item fur das gicht / domit geschmirt es hilfft.

Item fur die permuter drey oder vier tropffen eingenumen / vnd vmb den nabel damit geschmirt es hilfft.

Item fur den erbgrindt mit laugen rayn gewaschen vnd mit dem öll wol geschmirt es hilfft.

Auch sprechen etlich es helff fur den stinckenden attem / vnd fur das wildt geschoss / teglichen zwen oder drey tropffen eingenumen.

Diese obgeschriben gebrechen mag man alle heylen mit diesem öll spricht Platearius.

Disze obgeschrieben vñ noch vil mer tugent vñ crafft hat das hochgelobte Petroleon / welche vns beschriben sein / vnnd offt bewert / durch vill Doctores in welschen vnd teütschen landen / Nemlichen durch einen hochgelobten vnd weysen Doctorē Johannē von Karmona / welcher wunderliche ding zu Venedig beweret hat / zu lob dem almechtigen ewigen got / vnd zu trost vnd hilffe allen armen gebrechlichen menschen.

APPENDIX C

TEXT OF THE ANTWERP PAMPHLET (1540-1550)

La vertu de la Noble huyle / Laquelle est tres utile et profitable

pour plusieurs infirmites du corps

Petroliam est une huyle / quy (par la grace de Dieu le createur) sue et degoutte dune roche / par operation du soleil / en estrange et admirable maniere es regiōs du Duc de Ferraro aupres dune ville appellee Modene de la mñtaine Sybia. Laquelle est appellee baulsme de plusieurs gens par la grande et singuliere vertu / et daulcuns est elle nomme huyle de Sinte Katherine / au moien de laquelle ne demeure aulcune couleuvre ou telle venimeuse ala dicte montaigne que ne dechasse tout / combien que la region soit commune et encline a telle vermine. Laquelle vertu dela predicte huyle sensuyt.

Premierement ceste huyle purge et nettoye toute ulceratiō guarissant toute ancienne blesse / si on oigt icelle playe de la dicte huyle de une plume y apposant deux fois le jour une emplastre de Apostolicum.

Item elle donne secours a ceulx quy sont durs de ouye / ou quy ont quelque apostumation es aureilles / en posant une goutte ou deux avec du cotton en laureille elle guarist.

Item une femme enceynte denfant / si elle ne peut enfanter / elle prendra trois gouttes dicelle huyle en la bouche / et au nombril / les sains bien frottez de ladicte huyle / puis elle enfantera.

Item quiconque sera eschaude soit par feu eaue bouillant / ou poix / ou sera morfondu de gellee / il se frottera deux fois le jour de ceste petrolle.

Item ceste petrolle guarist touttes manierre de rongne / premierement on lavera et nettoiera tres bien les rongnes de biere chaulde / puis on le frottera deux fois le jour de petrolle / et soudain elle guarira sans faire rentrer lesdictes rongnes.

Item quiconque sera frappe ou mutile / ou tombe / de sorte que on en voie les perseures et apparance / quil le frotte deux fois le jour de petrolle et il se trouvera guarry.

Item quiconque sera blese interieurement / soit par avoir souleve quelque grande poids / ou soit quil soie cheut / desorte quil soie tout mutile par dedans

le corps / ou quil aie trop travaille / ou soit refroid / il prendra la demy foiroit entrer en la demie coquille dune avelaine ou noisette de ceste petrolle / et puis le boire avecq ung goblet de bierre chaulde / et puis le frottera sur le corps la ou il sentira la plus grande douleur / deux fois le jour.

Item celuy ou celle quy sera mordt dung chien rabbi / ou bien picque de une couleuvre / ou aultre venimeuse beste / frotera la plaie our morsure de ceste petrolle / et puis y mettra et posera une emplastre de apostolicum / et seurement il guarira.

Petrolle est aussy moult bonne a ceulx quy ont cramp / gouttes / ou paine et douleur que lhomme peut avoir es brachs et jambes ou en quelque endroit du corps / on se frottera sur la douleur deux fois le jour.

Ceulx aussy / quy se seront tranche ou perche / soit de coulteau / poinsson espinnes ou qelque aultre instrument / moiennant que quelque veine ne soie blessee / ou que la plaie ne soie si grande quil la convienne couldre ou rattacher il convient oingdre et frotter telle plaie avec une plume et faire degoutter une goutte de telle huyle / puis y apposer une emplastre / elle guarist en brief temps.

Item ceste petrolle est moult bonne pour douleur des yeulx / quy na encoire dure ung an / laquelle on messera avecq ung peu de laict de femme puis en oingdre les yeulx soir et matin.

Item de ceste petrolle on guarist enfants derompus / assavoir on oindra les enfants de ceste huyle / au lieu ou ils sont desrompus puis on prendra une petitte pieche de fustenne de la grādeur dung double patart / laquelle on mouillera de ceste huyle et puis on le pasera sur le lieu desrompu / le liant dessus avecq ung cousinet de jour et du soir.

Item pour celuy quy aura la chaulde pisse / ou granelle il frottera ses parties honteuses tout allentour et aussy la nombril / et se trouvera guari.

Item ceste petrolle est moult bonne encontre la pierre / on prendra pouldre de une pierre nomme lapis tinta laquelle on boulira en Petrolle / puis on le passera par ung drappeau / puis on lesclitera dune selingue ou esclitre au mēbre viril / et soudain la pierre se brisera ou diminuera / Mais le membre viril doibt premierement estre baigne et estuve deaue en laquelle sera boulu malve avecq huyle Daltue / che souvent a este esprouve es Italies.

Item contre toux ou estoupement destomach procedant de froidt / oignez la poictrine de ceste petrolle / puis beuvez la huictiesme partie de une once de ceste petrolle et aide moult a la personne.

Item contre enfleure de la matrice dune femme on prendra ung charbon ardant / dedens ung pot ou telle de terre / puis espandez de ceste huyle dessus puis vous estuvez dessus et telle odeur est fort aidable.

Item la femme quy est oppressee de la matrice / faicte un petit peloton de cotton puis le mouillerez de petrolle / puis lenfermerez au petit ventre / et

soudain que la matrice aura receupt odeur de la petrolle / elle se trouvera allegee / che que souvent a este experimente en Italie.

Item ceste huyle est plus convenables es froides regions / aux gents gras de froide nature / que non aux regions chauldes ou gents maigres / de froide complection.

Ceste petrolle a toutes ces vertus et encoire plusieurs aultres qui ne sont pas icy mētionnees / lesquelles ont estees souvent appliquees par moult scavants docteurs en Medecine / tout de Venise comme Ditalie / Allemagne et royaulme de France / principallement en la ville de Francquefort de deux experts docteurs en Medecine / nōmesmēt Maistre Jaspar et Maistre Alexandre / van Basel /residents audict Francquefort.

Sy quelqun / soit Apoticaire ou Medecin / a trouve ceste huyle predicte aultre que bonne / et aultre quelle vient da la Modene / il dovut perdre et fourfaire corps et biens.

Par moy Maistre Charles de Minne demourant en la renommee ville Danvers / lez le marche aux poulets / en la vieile rue du Lombardt / tenant les trois roses.

APPENDIX D

TEXT OF THE TEGERNSEE PAMPHLET

Ursprung, Wirkung und Gebrauch
des sogenannten
heiligen Quirin-Oeles,
welches bey Kloster Tegernsee in Ober-Bayern
aus der Erde hervor fliesst.

Zwey Gebether bey dem Gebrauche dieses heilsamen Oeles.

Heiliger Martyrer und auserwählter Freund Gottes Quirinus! ich bitte dich mit demüthigem Herzen, erhalte mir bey Gott durch deine Fürbitt, das er mir durch den Gebrauch dieses Oels die Gesundheit des Leibes, Wohlfahrt der Seele, Verzeihung meiner Sünden, ein glückseliges Sterbstündlein, und nach diesem zergänglichen Leben die ewige Freud und Seligkeit verleihen wolle. Durch unsern Herrn Jesum Christum, der mit dem Vater und heiligem Geiste lebet und regieret von Ewigkeit zu Ewigkeit. Amen.

Heiliger Quirinus! der du wegen Verachtung zeitlicher Hoheit von Gott durch das wundersame Wasser, welches unter deinem heiligen Leibe entsprungen, durch dein heiliges Blut, so aus deinem über 400 Jahre unverwesenen heiligen Leibe miraculoser Weise geflossen, und durch das heilsame Oel, so durch deine Fürbitt erfunden, und noch fliesst, herrlich und glorreich auf der Welt gemacht zu werden verdienet: erwerbe uns das Wasser reumüthiger Busszähren, und so steifen Vorsass, dass wir eher Leib und Leben, Gut und Blut aufsessen, als Gott mit einer einzigen freywilligen Sünde beleidigen, und erlange uns hiedurch das Oel des Heils, damit wir Gott in dir, und dich in Gott loben, ehren und preisen, mögen in alle Ewigkeit. Amen.

Dieses wunderbare Oel fliesst nicht weit von dem See jenseits des am Ufer stehenden St. Quirinbrunnkirchleins (in dessen Mitte der unter dem Wagen, wo der Leib des heiligen Martyrers im Jahre 752 von Rom übersesset worden, zu Nachts entsprungene nicht minder heilsame Wasserbrunn noch zu sehen ist) aus der Erde auf einer kleinen Wasserquelle hervor. Die erste Erfindung geschahe um das Jahr 1430 unter dem frommen und gottseligen Abt Kaspar. Es ergoss sich nämlich dieses Oel bey der Urquelle durch ein

kleines Gräblein mit dem herabfliessenden Wasser in den See, und floss in einer geraden und glänzenden Strasse gemeldten Kirchleins als gleichsam ihrem Urheber dem heiligen Quirino zu: absonderlich, da die über 300 Jahre gemachten Churen die Kräfte eines pur natürlichen Petrolei weit übersteigen. Ueber diese Urquelle wurde eine Behältniss gebauet, wo es noch beständig fliesst, und andächtig gesammelt wird.

Die wunderbarliche Kraft dieses Oeles wurde gleich anfangs in Heilung der Lamen und Gichtbrüchigen, besonders aber der durch das Feuer Beschädigten an Tag geleget. Mit der Zeit hat man erfahren, dass es auch in folgenden Umständen nicht so fast aus ihrer natürlichen Kraft (indeme es wegen ihrer Tröckne und Wärme durchdringet, resolvirt, und verzehret) als absonderlich aus einem kräftigen Vertrauen auf Gott und dem heil. Quirin geholfen hat. Und zwar:

1. Wider das Hauptwehe, Hauptgeschoss, Hauptdürre, Tob- und fallende Sucht ein oder mehrere Tropfen im Wein, Wasser oder anderem Getränke eingenommen, in die Nase, Schläfe, Haupt, Würbel und Puls angestrichen, stärket auch das Hirn.

2. Wider die Flüsse, Röthe, Überfelle und erblindete Augen mit einem Federlein ein oder andern Tropfen eingestrichen, verzehret die Felle, bringt wieder das Gesicht.

3. Für Flüsse und andere Verstopfungen des Gehöres, nimmt man eine Baumwolle, verstopft damit das Ohr, am welchen man übel höret, leget sich darauf, und lässt sich ein oder andere Tropfen in das gesunde Ohr giessen, so fliesst es durch das schadhafte Ohr hinaus, und bringet wieder das Gehör.

4. Wider das Zahnwehe, eine Baumwolle in das Oel eingetunket, und innwendig das Zahnfleisch damit bedecket.

5. Wider das Keichen, so von der Kälte herkömmt, und Husten, die Brust damit geschmieret.

6. Für Eitersucht, Lungen- und Leberfäule einige Tropfen im Wein, Meth, oder andern Getränke eingenommen.

7. Hilft zur Verdauung, und erwärmet den Magen, welcher auch von aussen kann geschmieret worden.

8. Wider das Grimmen ein- oder andern Tropfen eingenommen, auch über den Nabel etliche warme Tropfen in einer Baumwolle übergebunden.

9. Für die Gelbsucht etliche Tropfen eingenommen.

10. Wie auch wider die Würme bey Jungen und Alten in der Milch oder Wein eingenommen.

11. Wider die Harnwinde, Griess, Stein und Lendwehe zwey oder mehrere Tropfen im Wein eingenommen, wie auch selbige Theile, Lenden und Kreuz warm damit geschmieret.

12. So eine Frau von der Leibsfrucht ,oder Nachgeburt nicht kann erledigt werden, einige Tropfen im warmen Wein eingenommen.

13. Wider das Aufstossen der Gebährmutter den Rauch in die Nasen eingelassen.

14. In vergiften Contagiosen, als Petetschen, und Pestilenzzeiten frühe nüchtern 1, 2 bis 3 Tropfen davon eingenommen, und so etwann eine Person solche Zeichen hätte, dieselbe im Wein getrunken, und darauf geschmieret.

15. In Podagra, Chiragra, Zitrachen, Rauden und Grind, Flecken am Leibe oder Angesicht, Schachheiten der Glieder, oder Gliedersucht öfters warm angestrichen.

16. Ist es auch gut wider alle Geschwulsten, altlöcherige, faule und würmige Schäden an Menschen und Viehe, bringet die Milch wieder.

17. Hilft auch den Pferden für die Würme.

18. Bey Briefen und Kleidern in den Truhen aufbehalten, vertreibt die Milben und Schaben.

19. Wer die Hände mit diesem Oele, darinn Ganfer zerrieben, einschmieret, darf sicher und ohne Schaden alle giftige Nattern, Eyderen und Mollwürme fangen und angreifen.

APPENDIX E

TEXT OF THE TEGERNSEE PAMPHLET

Krafft, Tugend und Würckung des
Oels Sancti Quirini zu Tegernsee

Dieses Oel ist warm und trucken dahero es durchtringt, resolviert und verzehret:

Wider das Haubtwehe, Haubtgeschoss, Haubtthür, Tob- und fallende Sucht nicht allein 3. 4. oder 5. Tropffen in Wein oder anderen Getränck eingenommen sondern auch in die Nasen, Schläff und Pulsz angestrichen, stärckt es das Hirn, ist vilmahls bewährt worden.

Wider die Flüsz und Oberfell der Augen auch sonst erblindten mit einem Federlein eingestrichen, verzehret dasz Fell und wiéderbringet das Gesicht, welches auch vielmahls geholffen.

Welcher Flüsz und andere verstopffung des Gehörs hat der lasse ihme zwey oder drey Tropffen in das gesunde Ohr fallen, mit einer Baumwoll verstopfft, und aufs gehörlose Ohr gelegt, so fahret es durch dasselbe hinaus.

Wider dasz schmertzliche Zahnwehe inwendig dasz Zahnfleisch mit einer darein getunckten Baumwoll bedeckt.

Wider das Keichen so von Kälte herkommt auch alter Husten, die Brust damit gesalbet.

Welcher die Aitersucht hat, deme auch Lungen und Leber faulet, solle dessen 30. Tropffen in Wein, Meth oder andern Getranck einnehmen.

Es erwärmet auch den Magen, machet ihn wohlgeschickt zum verdähen, selbigen von aussen gesalbet.

Wider das Grimmen in einem warmen Wein 40. oder 50. Tropffen eingenommen, auch über den Nabl etlich warme Tropffen in Baumwoll übergebunden, und den untern Leib warm damit geschmieret.

Welcher mit der Gelbsucht, wie auch der rothen Ruhr behafft, der nehme von solchem etlich Tropffen ein.

In Milch oder Wein eingenommen, vertreibt die Würm in dem Leib bey Jung und Alt.

Wider die Harmwinde, Griess, Stein und Lendenwehe sowol 20. oder

mehr Tropffen in Wein eingenommen, als auch ober den Gemächten, Lenden und Creutz warm damit geschmiert.

Wider das aufstossen der Gebärmutter, den Rauch von diesem Oel in die Nasen und untern Leib eingelassen, auch den Nabel damit geschmiert.

Item so die Frauen von der Nachgeburt nicht können ledig werden, von 12. bis in 20. Tropffen in warmen Wein eingenommen.

In vergifften, contagiosen als Pestchen und Pestilentz-Zeiten frühe nüchtern 1. oder 2. Tropffen davon eingenommen, verhindert diese Krackheit und so etwa die Personen schon solche Zeichen hätten, bey 30. Tropffen in Wein getruncken und darauf gesalbet.

In dem Podagra, Frantzosen, Zitrichen, Räudig- und Gründigkeit, Flecken an dem Leib, oder Antlitz, Schwachheit der Glieder, erfrört, Gliedsucht, offt warm angestrichen.

Es ist auch gut wider alle Geschwulst, alte löchrigte, faule und wurmige Schäden an Menschen und Vieh, mit diesem geschmiert un darein gegossen.

Welches Rosz den Wurm hat, dem soll am ein kleines Bläter-Gläszlein voll eingeben.

Bey Brieffen und Kleidern in den Truhen aufbehalten, vertreibet allda die Müben und Schaben.

Wer die Händ mit diesen Oel, darin Saffran zerrieden, schmiert, darff sicher und ohne Schaden allerley gifftige Nattern, Eydexen und Moll-Würm fangen und angreiffen.

CHAPTER NINE

POURING OIL ON TROUBLED WATERS

In the year 1775 a booklet was brought out by the Leyden publisher Johannes le Mair entitled: "Berigten en Prijsvragen over het Storten van Oly, Traan, Teer en andere drijvende Stoffen in Zeegevaren" (Information and prize competitions in connection with the pouring of oil, train oil, tar and other floating matter in case of sea perils) from the pen of his townsman Frans Van Lelyveld (1740-1785). In his time Van Lelyveld was a well-known man, co-founder of the Society for the Promotion of Netherlands Literature and of the predecessor of the Netherlands Society for Industry and Commerce, cloth manufacturer, poet, man of letters and scientist, in fact a typical specimen of the progressive man of the 18th century who always had in mind the public welfare.

The author of this book on the pouring of oil on the waves was not a seaman, although he made very careful enquiries of seamen as regards the use of oil for calming the waves. His classical education at the Latin School immediately emerges when in the beginning of his preface he mentions that already Pliny the Roman speaks about oil on the waves. In order clearly to contrast this use of oil in antiquity with that in the latter days of our Republic, it is useful to quote the classical legends on this point in full.

Pliny, who in A.D. 79 at the great eruption of the Vesuvius became the victim of his curiosity, describes in the second book of his Natural History the natural phenomena which can be observed at sea. In doing this he says, inter alia: [1] "Against the typhoon they only have the slender remedy of pouring out vinegar in advance of its approach, vinegar being a very cold substance", a curious piece of popular belief which still lives on in Van Lelyveld's days, although beer is sometimes used instead. Somewhat further Pliny tells us [2] that "all sea water is made smooth by oil and so divers scatter oil from their mouth as they believe that the oil calms the rough element and carries light down with them."

[1] Pliny, Nat. Hist. II. xlix, 132.
[2] Pliny, Nat. Hist. II. cvi, 234.

A generation later Plutarch tells us in his Moralia [1] "of the other liquids oil is the most transparent, as it contains most air". This is proved by its lightness, owing to which it floats on any other liquid, kept up by the air. It also calms down the waves in the sea if it is poured out on them, as not the winds go away owing to the smoothness as is asserted by Aristotle, but because the waves, beaten flat by every fluid, spread. In particular oil gives lustre and clearness in the deep, as the water is spread by the air, for not only on the surface, for those who navigate at night, but also below the surface, at the bottom, for the sponge divers, spat out from the mouth, it lightens the sea."

The effect of oil, and here the author means, of course, olive oil, the oil par excellence of those days, was ascribed to its "nature", its being composed of a mixture of the four elements air, fire, water and earth, of which Aristotle had spoken in various places [2] which opinion Plutarch feels obliged to correct, although he agrees with the great philosopher that the "air content" of the oil is the principal cause. Plutarch further explains this again at another place [3] where he discusses the question: "Why does the sea become transparent and calm when it is sprinkled with oil?"

"For it is said that divers, when they spit out the oil they have taken in their mouth, bring about light and transparency in the deep. Look whether the oil, by its thickness, does not repulse and spread the sea—which is full of terrestrial components and uneven; further, when the sea returns and contracts, openings are caused which give transparency and clearness to the eyes. Or, is the air mixed with the sea, clear by nature owing to the heat, but does it become, when the sea is disturbed, uneven and dark? If the oil, by its thickness, smoothes the unevenness, does the air then get back its evenness and transparency?"

We shall now abandon these ancient theories regarding the structure of matter but bring on the stage a poet of the second century, Oppianus, who in his poem on fishes and fishery [4] describes somewhat more clearly how the sponge divers made use of the properties of olive oil: "A diver is girt with a long rope above his waist and, using both hands, in one he grasps a heavy mass of lead and in his right hand he holds a sharp bill, while in the jaws of his mouth he keeps white oil. Standing upon the prow he scans the waves of the sea, pondering his heavy task and the infinite water . . . When he takes heart of courage, he leaps into the eddying waves and as he springs the force of the heavy grey lead drags him down. Now, when he arrives at the bottom,

[1] Plutarch, Moralia 950 b-c, De primo frigido XIII.
[2] Aristotle, On the plants II. 823 a, 33-41 and Meteorologica IV, vii, 383b, 25-27.
[3] Plutarch, Moralia 914 f-915 b, Quaestiones naturales XII.
[4] Oppianus, Halieutica V. 634-649.

he spits out the oil, and it shines brightly and the gleam mingles with the water, even as a beacon showing its eye in the darkness of the night. Approaching the rocks he sees the sponges . . ."

We here abandon the ancient sponge fisher and note that apparently the ancients knew the calming effect of the fat olive oil on the waves and that their divers made the best possible use of this and also benefited by the clearness at the bottom which the stilling of the surface of the sea brought about. However, nowhere in ancient literature do we find any reference to the use of oil by ships during a storm. The ancients avoided navigating in stormy weather and even stopped navigation entirely in certain seasons. Even in the story of the shipwreck suffered by the apostle Paul on the coast of Malta no mention is made of the use of olive oil, which the vessel actually did have on board.

Reverting now to Van Lelyveld's book, we see that the author, on the contrary, aims at gathering data regarding the use of fatty oil to save ships in distress during a storm.

Van Lelyveld's attention in this matter was aroused by letters from Benjamin Franklin, Brownrigg and Parish, which were dealt with by the Royal Society in London on 2nd June, 1774, and published afterwards. [1] A short time before his first mission to England, Benjamin Franklin, being at sea in a large fleet bound against Louisburg, observed that the wakes of two of the ships were remarkably smooth, while all the others were ruffled by the wind. When he asked the captain the meaning of it, the latter answered: "The cooks have, I suppose, just been emptying their greasy water through the scuppers, which has greased the sides of those ships a little."

Since that time the problem haunted him, for he, too, knew the classical authors and their opinion regarding this question. In 1762, on his way back to America Franklin observed the relative quietness of oil floating on water in a swinging glass lamp. The captain told him that the fishermen on the Bermudas and in the neighbourhood of Lisbon emptied oil into the sea to ensure their being able to enter more safely through surf or breakers.

On a subsequent visit to England he even made experiments, together with Brownrigg, on Derwent water near Keswick in Cumberland, which experiments are the subject of his communications to the Royal Society. Thereupon he received all kinds of curious information. He mentions, inter alia, a letter from Captain Tengnagel to Count Bentinck in which he describes how, by gradually pouring in all "six demi-ames of olive oil" (465 1.) he managed to get through a heavy storm near the island of Amsterdam (Batavia) in the

[1] Benjamin Franklin, Brownrigg & Parish, Phil. Transactions vol. LXIV, pp. 445-460.

month of January, 1770. Another correspondent informed him that seal catchers can easily trace their prey when the seals are devouring a very oily fish, which they always do under water, as then the waves above are remarkably smooth, by which they betray their presence. According to Franklin the effect is brought about as follows: "that the wind blowing over water covered with a film of oil cannot easily catch upon the water so as to raise the first wrinkles, but slides over it, leaving the surface as smooth and even as it was before."

Back in London for the fulfilment of his mission, Franklin made further experiments, inter alia, in the pond of Clapham Common.

Franklin had been in Holland in 1760 and there he had met many scientists. So it was that one of Van Lelyveld's friends, Prof. Johannes Allamand, professor of mathematics and philosophy at Leyden, together with Count Willem Bentinck, could visit Franklin in London in the summer of 1773 and tell him, inter alia, of Tengnagel's adventure, which interested Franklin very much. For his foreign guests he then gave a demonstration in the pond of Green Park. "With some drops of oil" Allamand afterwards told at Leyden, "which, together ,would not have filled an ordinary table-spoon, he made the small waves disappear, which ruffled the surface of the water, in a circumference of at least 50 square rods."

Professor Allamand, together with the sea captain Willem May and the philosopher Cornelis van Engelen, was van Lelyveld's adviser and helper when the latter was writing his book. Captain May told him of a convoy of two ships loaded with olive oil, which had navigated in the Mediterranean in 1755. The oil leaking from the casks in the ship had been pumped out together with the bilge water and had saved these two ships from heavy wash of the waves. All such information strengthened Van Lelyveld in his intention to gather the data on this subject from his own country. For that purpose he addressed himself to various correspondents in fishing villages and ports of our coasts and received the most remarkable communications.

"From the information received by us so far, which we are now publishing we find that this practice of pouring oil, train oil, etc., into the sea to prevent surf and breakers, is fairly generally known by our Netherlands fishermen, among whom also the Greenland and Strait Davis whalers, but on board the merchantmen and the East-India traders only very little and on the men-of-war practically not at all, for which it would not be difficult to give the reason." He traces a remarkable prejudice of the fishermen against the pouring of oil, as they believe that the waves then wreack their rage on the other vessels.

"For", says Van Lelyveld, "this one pours oil, thus saving himself from

breakers and comes home safely, to learn there that two or three other vessels which were in his neighbourhood were wrecked in that same storm, and this happens very often. What is more natural for sailors than to think that because of that oil, which makes the sea around their ship even, the sea outside that circumference rages the more violently." This also deters them from reporting on the pouring of oil. Nevertheless he succeeds in gathering information from Zierikzee, Wijk aan Zee, Noordwijk, Maassluis, Scheveningen, Den Helder, Wieringen, Harderwijk and Middelburg, and is also informed of an unfounded belief that the pouring of oil was prohibited by edict!

Van Lelyveld himself, with Captain May and Professor Allamand, makes an experiment with some drops of oil on the water of the Oude Vest canal at Leyden on a windy day and sees the wonderful effect. According to information received by him, linseed oil was more efficacious than train oil, at least according to fishermen, who break the surf with it before entering the harbour. Most of the reporters conclude: "that the train oil or oil or any fatty matter which cause a large even patch on the water, cannot prevent the rolling of the sea and the running of the stream, but it actually can to a large extent suppress or do away with surf and breakers."

Van Lelyveld then formulates some sixteen questions, offering a prize for the best answers. He is interested not only in knowing what kind of oil is most efficacious, but also in a statement of the exact quantity which has to be poured, how long the means is effective, whether it will also help large vessels, whether it will not be detrimental to eel and other fisheries and whether the effect has anything to do with the type of vessel. The prize competition had to be answered before the 1st of May, 1776, and the award was a "premium of thirty ducats or a medal of honour of equal value".

We do not know whether this prize contest was a success, but no doubt Van Lelyveld's treatise caused reactions in those circles which he accused of ignorance as regards the pouring of oil on the waves. The Chambers of Amsterdam and Zealand of the V.O.C. (United East-India Company) took the advices given very much to heart and in the Resolutions passed by the meeting of the "Board of Seventeen" at Amsterdam on 10th April, 1775 it was decided to authorize the skippers or masters of their ships to make further experiments. Recently Hallema has published various reports. [1] Such trials were not quite superfluous, for the seaworthiness of many ships and the seamanship of many masters and officers of lower rank were, then, to an alarming extent, inferior to what they were in the 17th century and shipping disasters were the order of the day. Presumably this is also one of the (unexpressed) reasons which induced Van Lelyveld to write his booklet.

[1] Hallema, Marineblad vol. 62, 1953, pp. 269-285.

The reports from the East-India men date from 1781, 1783 and 1777. Later we are also informed of experiments which the navy ordered to be made in 1843. The results of these experiments proved Van Lelyveld was right and in particular disclosed that the oil has to be poured only in small quantities, as just a thin layer of oil has the desired effect. It is not known to us whether the above led to an instruction in this respect being issued.

It is, however, illustrative of the inadequate co-operation between natural science and practice in our country in those days that neither Van Lelyveld and his friends, nor the East India Company fall back on the studies regarding the manner in which waves are caused by the wind, which studies, as a matter of fact had already been initiated long ago by Huygens and Newton (1687) were continued in our country by 's Gravesande and just at the time of Van Lelyveld's book were attracting attention as a result of publications by Bernoulli (1738), Euler (1777), Laplace (1779) and Lagrange (1786). These were to be continued in the 19th century by Gerstner (1802), Poisson (1816), Cauchy (1815) and Thomson (1871), the latter pointing to the importance of the surface tension in this problem. The "energy" considerations regarding the producing of waves were beautifully formulated by Helmholtz (1890) and Wien (1895-1897).

Taking as a basis Helmholtz's remarks regarding the surface tension, Sohnke then studied the thickness of an oil layer on the point of breaking, [1] which investigation was rounded off by Röntgen [2] and Oberbeck. [3] Van Lelyveld's data proved to be surprisingly correct. In particular the fatty oils, such as coco-nut oil, ground-nut oil, olive oil and train oil, in very thin layers of a thickness of some molecules, have a great effect on the surface of the water. The fatty acid molecules direct themselves in a special way and hook themselves, as it were, with their fatty-acid group into the water, so that, so to speak, a rubber mat is spread over the water and the wash of the waves is broken, but naturally the smell cannot be suppressed. Petroleum, which consists of hydrocarbons, has a similar effect only in a very slight degree. The pouring of oil, which the fishermen and sponge divers of ages ago had already found an efficacious means—freed from superstition in the light of science —proved to be an extremely interesting and active means, although at present it is hardly applied any longer, except by lifeboats.

[1] Sohnke, Wiedemann's Annals 40, 1890, p. 344.
[2] Röntgen, Wiedemann's Annals 41, 1890, p. 321.
[3] Oberbeck, Wiedemann's Annals 49, 1893, p. 366.

CHAPTER TEN

FROM WASTE MATERIAL TO RAW MATERIAL FOR THE CHEMICAL INDUSTRY

For many centuries the history of tar was closely connected with that of metallurgy. As long as charcoal was used to smelt ores, wood tar was obtained as a by-product of the carbonization process. At a later period coal was made suitable for the reduction of ores by coking, in which process coal tar was produced in greater quantities; and uses were gradually found for this latter product at the expense of wood tar.

1. *The Age of Wood Tar*

After charcoal had been used in metallurgy for centuries, it was inevitable that the tar should be observed, extracted and employed. References can be found in the writings of classical authors which show that there was a long experience of this substance. Charcoal was burned in circular stacks (Dutch "mijt", which is derived from the Latin "meta", a cone shaped mound; this makes it clear how the wood was piled in layers for carbonization). People were aware of the close connection between the grain of the wood and the quality of the charcoal obtained from it. [1] The tar was drawn off from the bottom of the stack in channels 16 ells long. Pliny recommends charcoal burning in brick "furni" or "alvei" in his Natural History. [2] He reports that the first liquid to run out was a light tar which the Syrians called "cedar juice" and which was used in Egypt for embalming corpses. As the carbonization process continued, a more viscous liquid was obtained which was suitable for making pitch. To this end the tar was boiled together with vinegar. The pitch thus produced was called "Bruttiae", probably because this was the method customary at Bruttium (Southern Italy). This pitch was only suitable, however, for the sealing of casks.

From the resins obtained by cutting notches in pines, a pitch was produced which was employed for various purposes. Theophrastos describes how

[1] Pliny, Nat. Hist. XVI. 21-23; Theophrast. Hist. Plant. III. 8. 5-7; V. 9. 2-4; IX. 3. 1.
[2] Pliny, Nat. Hist. XVI. 52-61.

briquettes, which form an excellent fuel, can be made from charcoal, pitch and tar. [1] Pitch was further used as a core for statues and for modelling; [2] also for caulking pots, [3] ships, [4] walls and roofs; [5] and as a colouring material, paint, or rustproof coating for metals. [6] Bunches of spruce twigs, rope or tow dipped in hot tar had been used for centuries as torches. [7] By burning tar or pitch under a lid or covering (later in a special sealed compartment) lampblack was obtained which was used as a pigment. [8] It is even stated that the light ingredients can be caught in a skin stretched over a cauldron of boiling tar and this "tar oil" then collected by wringing out the skin. [9] Tar produced by dry distillation from various base materials played then, and still plays, a part in magic and in folk-medicine.

The production of tar, however, was not the main purpose of this charcoal burning. It was obtained only in relatively small quantities and for many centuries we find only isolated reports about the application of tar and pitch, which were both still produced almost as in Pliny's time. Around 1100 the monk Theophilus [10] recommends tar and pitch as protective agents for iron locks and fittings. He also gives a recipe for a mixture to be used in beating silver which must be neither brittle nor soft. "Melt pitch together with wax and add brick dust; after stirring well, put the mastic into water and knead thoroughly. The silver may be later laid on top of this composition and beaten into the desired shape". Leonardo da Vinci used a mastic made from pitch and brick dust for priming paper. [11]

With the development of navigation, especially after the discovery of the New World and the increasing exploration of the seven seas, the demand for tar and pitch grew. The durability of the various types became a factor of increasing importance. Turner (in his "Herbal", 1551) states that "the French obtain a juice called bitumen from birch trees" which affords very good protection to wood. In 1688 Dr. Elias Codde van den Burgh of Holland obtained a patent for "Cypriot Tar", which was said to be specially suitable for tarring cordage, wood and iron and also to be four times more durable

[1] Theophrastos, De Ign. 37.
[2] Lukian, Iup. trag. 33.
[3] Pliny, Nat. Hist. XIV. 134; XV. 62.
[4] Pliny, Nat. Hist. XVI. 56 & 158.
[5] Pliny, Nat. Hist. XXXVI. 166.
[6] Pliny, Nat. Hist. XXXIV. 99; Pausanias I. 15. 4.
[7] Homer., Ilias XI. 553.
[8] Dioskorides I. 84 & 93.
[9] Pliny, Nat. Hist. XXIV. 24; Dioscorides I. 95.
[10] Theophilus Presbyter, Diversarium Artium Schedula, edit. Johannsen, V.D.I. Verlag, Berlin, 1933, Buch III, cap. XCI.
[11] Berger, Beiträge zur Entwicklung der Maltechnik (München 1904/09).

than ordinary tar. [1] A year previously A. de Gerente of London had obtained a patent for treated tar. [2]

In the meantime scientists had begun to concern themselves with the origin and composition of tar. Boyle observed the dry distillation of wood in a fire, [3] and Glauber separated several substances by the dry distillation and fractionation of organic matter. These substances were later rediscovered in the 19th century as important ingredients of coal tar. [4]

With the progressive industrialisation of Western Europe, deforestation increased and, as a result, the charcoal industry moved northwards (Scandinavia and Central Europe) and to the colonies in the New World. The methods changed but little, [5] and the brick kilns or circular stacks scarcely differ from those described by Pliny. [6] This becomes evident if we consult a work like Zedler's "Universallexikon" (Vol. 43, 1745), where the manufacture and use of wood tar are described as follows:

" "Theer", "Ther", "Teer" or "Ter" is the name of a substance which the French call Goudran or Goudron. The Dutch call it Teer, the Latinists axungia, pix fluida or pix liquida. It is a clear resinous oil which the tar burners extract by fire from spruces and pines or from the trunks and roots of resinous trees, in specially designed kilns at the tar works. It can be made in three ways. By the first method the spruce and pine wood is put into a small stack and burned until carbonized, the tar running out at the first fomentation and being collected in a basin made of size; or alternatively the appropriate wood is burned in a pit, or in specially designed tar kilns and the tar then collected in a near-by hole. But because it is no longer permitted in many places to make tar from stem timber, pine stumps and roots are at present being used and the tar is extracted from them in kilns. A lot of tar is still made in Germany intermittently, but the most and best comes from Sweden and Norway, best of all being that from Gothland. The four varieties in which it is sold are as follows:

1. The thin type, as clear and pure as oil;
2. The rigging tar, which turns granular;
3. The medium thick type;
4. The very thick type.

These have all to be bought from the licensed tar company in Sweden. Many thousand casks per year are transported to the sea ports, where they are stored

[1] Patent der Staten Generaal 532 of 29. 10. 1688; Staten van Holland 172 of October 1688.

[2] Patent der Staten van Holland 168, March 1687.

[3] Robert Boyle, The Sceptical Chymist (Everyman's Library, London, 1910, 36 & 109).

[4] Joh. Rudolf Glauber, Furni novi philosophici, oder Beschreibung einer neu-erfundenen Destillier Kunst (Amsterdam, 5 Teile, 1648-1650).

[5] M. Schofield, The Rise and decline of charcoal burning (Science progress vol. XXVI, 1932, pp. 654-661). — Reisner, Aus der Geschichte der Holzdestillation (Z. f. Angew. Chemie, vol. XXXVII, 1924, p. 233).

[6] W. Weicker, Ein alter Holzteerofen in Thüringen (Technikgeschichte, vol. XXIII, 1934, p. 134).

outside the towns in special buildings as a precaution against fire, for tar is a highly inflammable material. It is used chiefly in shipbuilding, for tarring the cordage and the ships themselves so that they are protected against decay in water and rain. Carpenters use it to tar the tops and ends of beams as far as they lie in the wall, as well as other woodwork which is exposed to air or water, such as canopies, gutters, etc. Innkeepers and carters use it with cattle and on the axles of their vehicles to make them run better and less subject to jolting. According to the Breslau Natural Histories, 9th collection, p. 320 et seq., tar is an excellent remedy for the plague, both for people and cattle, and makes urine smell of violets."

2. *The Age of Coal Tar*

Coal, to which in ancient times there were only vague references, came into use around 1300 for the smelting of crude iron. The ever increasing shortage of wood as a fuel and as a raw material for charcoal burning hastened this development, even though the gaseous and tarry constituents caused metallurgists and glass and soap makers great inconvenience. Although Dun Dudley asserted that iron could be smelted with fat coal, [1] it was still a long time before the coking of coal was mastered. [2] Successful coking was due mainly to Abraham Darby, who in 1709 coked coal in stacks. Two successive generations of Darbys perfected this process. Towards the end of the 18th century the English metallurgists went over to using brick bee-hive ovens for making coke, tar being obtained as a by-product. Similar ovens were being used in Saarbrücken in 1768 [3] and in the Ruhr around 1780, and were generally preferred. The older method of coking in stacks was forbidden around 1832 on account of the evil smell.

Before this new source of tar was developed, many people had, time and again, indicated the necessity for making tar out of other raw materials. One of these men was Thomas Spratt (1667). [4] Thirty years later Martin Eele announced that he had produced tar by the dry distillation of oil shale. [5] Just before this Becher [6] had been granted a patent for the manufacture of tar and pitch from coal, without, however, obtaining any economic results. Yet another century was to pass before the utilization of coal tar was cham-

[1] Dun Dudley, Metallum Martis (London, 1665).

[2] Rhys Jenkins, Coke, a note on its production and use, 1587-1650 (Trans. Newcomen Society vol. XII, 1931/32, pp. 104-107). — H. Gwynn Jones, The Charcoal Industry (J. R. Soc. Arts vol. 88, 1939, pp. 41-57).

[3] De Gensanne, Traité de la fonte des mines (Paris, 1770, vol. I, cap. 12).

[4] Thomas Spratt, History of the Royal Society (London, 1667, p. 221).

[5] Martin Eele, An Account of the making of pitch, tar and oil out of a stone in Shropshire (Phil. Trans. vol. XX, 1697, p. 544).

[6] Becher and Serle, A new way of making pitch and tar out of Pitt Coal, never found out or used by any other, Engl. Patent No. 241, 19 Aug. 1681.

pioned by someone who concerned himself with the practical development of this idea. Archibald Cochrane, Ninth Earl of Dundonald was an adventurous and inventive man, [1] and his contemporaries regarded his patent [2] as of greater national importance than that of James Watt or the latter's new steam engine. He succeeded in doing what others had already attempted—making the production of tar from coal a paying proposition.

Dundonald (1749-1831) had at first attempted to make a career for himself in the army and navy, in the course of which he visited among other places the pitch lake in Trinidad. When he inherited the title and the estates at Culross Abbey (Scotland) in 1788, he sought to increase the family fortune by opening up coal mines of his estates. As a naval officer, during voyages off the west coast of Africa, the idea had come to him of making tar from coal to combat the attacks of the ship worm (teredo) on wooden ships. Dundonald was no financier, and his attempts to set up tar works at Culross would almost certainly have come to naught, had he not managed, with the help of others, to found The British Tar Company. In September 1782 this company started up its ovens for converting coal into coke and tar. His patent had then been in force for only a short time, and he concerned himself with creating a firmer foundation for the young company. He asked Parliament for an extension of his patent and in 1785 he was granted an extension up to 1806. In the same year he wrote a book [3] in recommendation of tar and its by-products, such as coke, lampblack, ammonia, sal ammoniac, etc.

Dundonald had hoped to be able to conclude a large contract with the British Navy, which, however, refused to use tar, since—as Kirwan explained [4] —tar was too good and the ships would then only seldom require repairs! It was not until 1822 that the Admiralty abandoned the expensive copper sheeting for protecting its vessels against teredo and on Davy's recommendation began to use tar. [5]

The British Tar Company founded tar works near the Scottish iron mines on the Firth of Forth and in England. These tar works sold their coke to the iron works. The invested capital in 1788 amounted to £ 22,400 and brought in annually a clear profit of £ 5,000. The works at Muirkirk became involved

[1] A. Clow and Nan L. Clow, Lord Dundonald (Economic History Review, vol. 11, 1941, pp. 47-58). — K. R. Webb, The story of the distillation of coal (Chemistry and Industry vol. 62, 1943, pp. 158-159).

[2] Archibald, Earl of Dundonald, Engl. Patent No. 1291 (1781): Manufacture of tar and pitche from pitcoale.

[3] An Account of the Qualities and Uses of Coal Tar and Coal Varnish, with Certificates from Ship-masters and Others (1785).

[4] Richard Kirwan, Experiments on the composition and properties of carbon in bitumens (Phil. J. vol. I, 1797, p. 487).

[5] Council Minutes (Royal Society) vol. X, 4.

in a dispute with the Kaims colliery, the owner of which was John Loudon Macadam, the famous road builder. The Muirkirk tar works finally passed into Macadam's hands and were closed in 1829, without Macadam ever thinking of "tar macadam", which seems to us such a logical development. The first experiments with tar macadam date from the period 1832-1838 (Nottinghamshire, England). Twenty ovens were in operation both in Culross and in Dalkeith, producing volatile oil and resin (together worked up into varnish), boiled tar, cinders (coke), volatile alkali (ammonia) and sal ammoniac. Dundonald may well be regarded as the pioneer manufacturer of ammonia and sal ammoniac when one considers that ammonia had only been discovered by Priestley in 1774 and that Berthollet had not ascertained its composition until 1785!

Soon, however, tar was being obtained from sources other than the making of coke for the metal industry. In his experiments Dundonald had already considered coal gas as an illuminant. But William Murdock, [1] unaware of Dundonald's experiments and with the work of Lebon, Argand and Minkeleers as his basis, had already demonstrated the virtues of gas lighting. Winzer, who between 1801 and 1810 had tried in vain to find money in Germany to develop the production of gas, was successful in England and founded the Chartered Gas Light and Coke Company.

Lampadius carried out successful experiments in Freiburg from 1811 to 1816, and in 1825 William and Drory built in Hanover the first German gas works. A new source of coke and tar was opened up, thanks especially to those researchers who, after the example of Accum and Clegg, had undertaken a detailed examination of tar. What Henry Haskins had vainly attempted in 1764 [2] now became reality. Tar was to become an important base material for the chemical industry. [3] In 1815 F. C. Accum was already producing "naphtha" by distilling coal tar and was using it as a lampfuel and as a solvent for enamels and varnishes, and in the processing of rubber. In 1838 Bethell discovered the wood-preserving quality of the creosote fraction of tar.

Garden and Kidd separated naphthalene from tar in 1819, [4] and Faraday separated benzene from illuminating gas in 1825. [5] Reichenbach described the formation of naphthalene by dry distillation at a high temperature, [6] and

[1] William Murdock, Utility and advantages of gas-lights (Phil. Trans. 1808, p. 124).
[2] Henry Haskins, Engl. Patent No. 619, August 7, 1764 New Method of Extracting a Spirit or Oil out of Tar, and by the same process produce the finest of Pitch.
[3] H. Wiesenthal, Naphthalin und Anthrazen (Teer und Bitumen vol. XXXVII, 1939, pp. 92-94).
[4] Philos. Trans. 1821, p. 209.
[5] Philos. Trans. 1825, p. 440.
[6] Pogg. Ann. Bd. 28, 1831, p. 484.

Laurent examined the derivatives. [1] In 1832 Reichenbach made creosote from wood tar. Two years later Runge gave an account of his fundamental investigation of tar fractions; he produced the first tar dye [3] as well as rosolic acid, carbolic acid, "cyanol" (aniline), "leukol" (quinoline) and pyrrole. Dumas and Laurent obtained anthracene from tar in 1835; [4] phenol followed in 1841, [5] and a year later Leigh discovered benzene in tar, this being confirmed by Hofmann in 1845. [6]

These few examples will illustrate that by 1850 the most important constituents of tar had been discovered and that their properties were known. Gas and coke works produced large quantities of tar as a by-product, which in turn provided the said material for an expanding chemical industry.

[1] Ann. de Chimie, Sér. III, Bd. 51, 1832, p. 270.
[2] Schweiggers J. Bd. 65, p. 461; Bd. 66, pp. 301 & 345.
[3] Pogg. Ann. 31, pp. 63 & 315; Bd. 32, p. 308.
[4] Ann. de Chimie, Sér. II, Bd. 60, p. 220.
[5] Ann. de Chimie, Sér. III, Bd. 3, p. 145.
[6] Ann. Bd. 55, 1845, p. 200.

CHAPTER ELEVEN

JOYFULL NEWES OUT OF THE NEWFOUND WORLDE

For two centuries after the discovery of the New World by Columbus (1492) nearly every fleet that sailed west was able to discover some new island or new coast. Hence these two centuries are filled with reports and descriptions of new tribes and peoples, plants and animals, minerals and other natural products. Among the latter we hear of new seepages and bituminous substances found in the New World.

Probably the first seepage of thick asphaltic oil found in these regions was that of Puerto Principe, Cuba. The town of Havana was often called Carine "because ships careened there"! This thick crude is first mentioned by Oviedo y Valdés [1] in 1526, who tells us about the thick asphalt of Puerto Principe used for painting the hulls of ships as is that from another seepage on the shore of Havana harbour. Further details on this "pitch" is given by Monardes [2] in 1565. Monardes' book was "englished by John Frampton, merchant, anno 1577" and published in 1596. A new edition of this English version of Monardes is now available. It tells us "of the Betumen which is a kind of Pitch. There are in the Islande of Cuba certain Fountaines at the sea side, that doeth cast from them a kinde of black Pitch of a strong smell, whiche the Indians doe use, in their cold infirmities; our people doe use it there to pitch their shippes withall, for it is well nere like to tarre, and they doe mingle therewith with Tallow, for to make it pitch the better. I do believe that this is Napta, whiche the ancient writers doe speake of, Possidonio doth say, that there are two Fountaines in Babilon, one white and the other black. This that they doe bring from the Indies, we doe use it in griefes of the

[1] G. Fernández de Oviedo y Valdés, Sumario de la naturel y general istoria de las Indias (Toledo, 1526) (modern edition Madrid, 1853).

[2] Nicolas Monardes, Historia medicinal de las cosas que se traen de nuestras Indias Occidentales (Sevilla, 1565) (Engl. edition by John Frampton, Joyfull Newes out of the Newfound Worlde, E. Alde, London, 1596).

[3] Edition Tudor Translations, Second Series, edit. St. Gaselee, Constable, London, 1925, vol. I, p. 19.

Mother." The pitch of Puerto Principe is also mentioned by Paul Boccone as a product imported from the West Indies about 1700. [1]

The second group of seepages noticed by the Spaniards was located in the ancient Inca Empire, in the present states of Ecuador and Peru. Monardes [2] is probably describing a rockasphalt refined by the ancient "destillatio per descensum" method (Chapter V) when he refers to "a Gumme that is taken out the Grounde":

"In the Collao (the present Titicaca region) beying a countrie of Peru, there is a province which doeth not beare any Tree or Plante, for because the Grounde is full of Gummes, and of this Grounde the Indians dooeth take out a licour that dooeth serve theim to heale many diseases, and to take it out thei use it in this forme. Thei doe make in the Yearth certaine sesternes very great and thei doe put them upon timber, or canes, and underneath they putte a thyng, that maie take the liquor which commeth out of them, and thei putte them into the Sunne, and with the heate and strength of it, the gumme is melted or the liquor which the yearth hath, and the Sesternes doeth remaine without any liquor, the which doeth profite to make fire of them, for in that place there are no trees nor any other thyng to make fire: and it is an evill light for it dooe caste out a black smoke, and an horrible smell and for all this, seeying thei have no other thyng to make fire of, thei passe with it.

The licour whiche doeth come forth of it, doeth profite for many deseases, and especially when it dooeth depende of colde, or cold causes, it taketh awaie any greefe of the saied cause, and the swellynges which dooeth come of it; thei heale with it woundes and all the evilles. That whiche thei sente me is of a redde coullour, somewhat darke and it hath a good smell."

More frequent are the references to seepages of crude oil in the neighbourhood of the present Lobitos oilfields. They are first mentioned by De Zarate [3] who travelled in Peru from 1544 to 1551 and who says that at 2° South there is "a cape or point which the Spaniards named Santa Elena, wherein are found certain springs of pitch (pez) or tar (alquitran) and it serves for the same purpose in ships". Father de Acosta [4] who travelled in Peru from 1569-1583 has a similar note:

"At the point of Cape Santa Elena there is a spring or fountain of pitch, which at Peru they call "copey", the mariners use this copey to pitch their ropes and tackling."

[1] P. Boccone, Museo di Fisica (Venezia, 1697, p. 32).

[2] Edition of Frampton's translation in the Tudor Translations (London, 1925, vol. II, p. 24).

[3] Augustin de Zarate, Historia del descrubiemento y conquista del Perú (Martín Nucco, Antwerp, 1555) (Vol. I, cap. 5).

[4] Father José de Acosta, Historia Naturel y Moral de las Indias (Book III, cap. 17) (Juan de Leon, Sevilla, 1590).

In 1640 Barba [1] mentioned that "asphalt was not unknown, for it occurs in large quantities in the Los Chiriguanas mountains on the Lomina frontier. This country is little known, its inhabitants have not been subjugated and that is why they are called the Warrior Indians." About 1700 Father De Velasco again mentions the production of pitch at Santa Elena [2] and he believed that is was used as a mortar after being mixed with lime, for he states:

"They prepared quicklime by the same process in use in Europe and they mixed it thoroughly with a kind of bitumen which Gomara discusses in the 194th paragraph of his Historia general. This wonderful mixture the secret of which with so many others we have lost through the carelessness of the first conquerors, was much better than that which European architecture uses; for it was not used to increase the extent of the building, but simply to join the stones strongly together; it was very fine and very sticky; only just enough was put on, in the same way as joiners use their glue to join two pieces of wood.

The Europeans, seeing that the stones touched each other without being separated by a layer of lime one or two inches thick, thought that they were not joined by any cement at all, whereas on the contrary this cement was so good that, as I had the opportunity to see with my own eyes, it is easier to break these stones with picks and crowbars than to separate them when they are joined by this inconspicuous cement, but for which water and air would have got into tanks, baths and fountains, the raised margins of which were usually separate and unsupported."

We do not know where Father De Velasco took this note on the bituminous mortar of the Incas, which story has not been substantiated by modern archaeologists. Maybe we should trace it back to the classical stories on the bituminous mortar of the inhabitants of Mesopotamia.

Third in succession was the discovery of the famous asphalt lake of Trinidad. We do not know when the Spaniards first started to use this asphalt but our earliest detailed reference dates from 1595. In February that year Sir Walter Raleigh left England and reached Trinidad on March 22nd where he visited a place called Parico: [3]

"From thence I rowed to another part, called by the naturals "piche" and by the Spaniards "Tierra de Brea" . . . At this point there is that abundance of stone pitch, that all the ships of the world may be therewith loden from thence, and wee made triall of it in trimminge our ships to be most excellent good, and melteth not with the sunne as the pitch of Norway, and therefore for ships trading the south partes very profitable."

[1] Métallurgie ou l'art de tirer et de purifier les métaux, traduite de l'espagnol d'Alphonse Barba (edit. Gosford, Paris, 1751, 2 vols., vol. I, p. 32).

[2] Father Juan de Velasco, La Historia del Reino de Quito . . . (Mss of 1789, edited by Don Augustín Yerovi, Quito, 1841-1844, 3 vols.) (French edition H. Ternaux-Compans, Paris, 1840, vol. I, pp. 126-128).

[3] Sir Walter Raleigh, The Discoverie of the Large Rich and Bewtiful Empire of Gviana . . . (Robert Robinson, London, 1596).

From other sources [1] it is evident that the Carib Indians knew the asphalt lake of Trinidad and visited it from time to time and that the Spaniards never knew it. It has also become evident that neither Raleigh nor his cousin Robert Dudley who visited the same coast of Trinidad some months earlier actually saw the asphalt lake, they seem to have found only shore asphalt, blown up by the waves to the shore from seepages on the bottom of the lagoon. The great inland asphalt lake itself was not described until 1786 when de Léry visited it. From that date onwards we find more detailed descriptions of the nature of the lake asphalt and its possibilities.

In 1789 Anderson says that the lake asphalt "answers the intention of ship pitch". He describes areolae on the surface of the lake and find that at a depth of one feet the asphalt is already much more oily. "I take this bituminous substance to be *Bitumen Asphaltum Linnaei*. It is most useful as a preservative against the Borer (teredo) so destructive to ships in this part of the world. A liquid form is to be found in many parts of the woods but it smells stronger of tar. This oil is from 20 to 22° F hotter than the atmosphere." [2]

Dr. Nicolas Nugent says he heard it related that "when the Spaniards undertook formerly to prepare the pitch for economical purposes, and had imprudently put their cauldrons on the very Lake, they completely sank in the course of a night so as to defeat their intentions." [3]

Modern exploitation can be said to have begun with the visit paid to the Lake by that versatile and ingenious seaman Admiral Thomas Cochrane, 10th Earl of Dundonald (1775-1860) on February 11th, 1848. His examination of the Lake and its products gave rise to a series of patents (1851-1853) on the applications of Trinidad Lake asphalt and other bituminous substances. [4]

Neither do we know exactly when the seepages of thick crude on the island of Barbados were discovered. It is mentioned by many eighteenth-century authors (such as Boccone [5]) and dictionaries. Hughes [6] tells us that:

"As our most remarkable Fossils are of the Bituminous Kind, I shall begin with the green Tar.

[1] Percy E. Spielmann, Who discovered the Trinidad Lake Asphalt? (Science Progress, July 1938, No. 129, pp. 52-62).

[2] Anderson, An account of the bituminous Lake or Plain in the Island of Trinidad (Philos. Trans. vol. LXXIX, 1789, p. 65).

[3] N. Nugent, Account of the Pitch Lake of the Island of Trinidad (Trans. Geolog. Soc. vol. I, 1807, p. 63).

[4] English Patents No. 13.698 of July 22, 1851; No. 277 of October 6, 1852; No. 496 of February 1853; No. 1347 of June 1, 1853. — A. W. Attwooll and D. C. Broome, Trinidad Lake Asphalt (Baynard Press, London, 1935).

[5] P. Boccone, Museo di Fisica (Venezia, 1697, p. 32).

[6] Griffith Hughes, Natural History of the Island of Barbados (London, 1750, pp. 50 & 51).

This is an oily Bituminous Exudation, issuing from some Hills in St. Andrew's and St. Joseph's Parishes, of a dirty Black, inclining to a Green.

The Method of procuring it is, to dig an Hole or Trench in, or very near, the Place where it ouses out of the Earth: This by degrees fills with Water, having a thick Film, or Cream, of this liquid Bitumen swimming upon the Surface; from whence it is skimmed off, and preserved in earthen Jars, or other Vessels.

The most convenient Season for gathering it is in the Months of January, February, and March.

It is of so inflammable a Nature, that it serves to burn in Lamps.

As to its medicinal Qualities, it is chiefly made use of with great Success in paralytic and nervous Disorders, as well as in curing cutaneous Eruptions. It is of so penetrating a Nature, that when an Horse, that hath been dosed with it, begins to be warm upon his Journey, the Rider will smell the Tar very strongly.

This, and one of a blacker Colour, in St. Joseph's Parish, are all the liquid Sorts found in this Island. There is likewise another Species of Bitumen, of a solid Substance, called here Munjack (now called "manjak"). This is dug out of Beds, or Strata, of Earth, at different Depths, in the Sides of Hills in St. John's and St. Andrew's Parishes; and nearly answers the description of that Bitumen, which the Reverend Mr. Maundrel found on the mountainous Sides of the Lacus Asphaltites, or the Dead Sea, where formerly stood the Cities of Sodom and Gomorrah. This Sort, in a great measure, answers the Use of Coals.

Where the liquid Kinds are thrown up out of the Earth, the Surface of the Ground is one continued Quagmire, bearing very little, if any Grass; and where the more solid is dug out, if the Veins are upon, or very near the Surface, scarce any Vegetable grows upon it. If by Accident any of these Veins take Fire, they continue to burn a long time, tho' in a dull slow manner: For, as the Veins are surrounded with Earth, this crumbles, and falling into the Flame, stifles it. There was an Instance of this in St. John's Parish, where a Slave roasting Potatoes upon the Side of an Hill, a small Vein of Bitumen, lying very near the Surface, took Fire, and continued slowly to burn, tho' sometimes scarce perceptibly, for above Five Years, without the least Danger to the Neighbourhood."

"However", says Hughes, "one should not conclude from such reports, that the destruction of Sodom and Gomorrah was caused by a natural phenomenon like Monsieur Le Clerc does, who believes that the plains full of bitumen near these towns caught fire by a stroke of lightening" and he goes on to prove his point.

It would seem, that (although Hughes does not mention this) "Barbadoes tar" was exported to Europe, where we often find it on lists in handbooks as a substitute for "Norway pitch" or "Swedish tar". The crude seems to have been used as a medicine in certain cases in Europe, for the treatment of lepra and cancer of the breast. [1] However, no important oilfields have been developed in this island.

[1] T. P. Pierce, An account of the use of petroleum barbadense in the treatment of lepra and on occult cancer of the breast (Medic. Comment., Edinburgh, 1791).

We do not hear about the seepages of the Argentine and Venezuela. It is quite possible that there was some local exploitation of such seepages by the natives of Venezuela for many centuries as there undoubtedly was in Mexico. There is some positive evidence on the use of "chapopotli" in ancient Mexico. This word denoting bitumen is said to have been compounded from "tzauc, tzacutli" (cement) and "popochitli" (perfume) as the natives used it both for waterproofing and cementing their pottery and for ceremonial incense together with (or as a substitute for) copal resin and aromatic substances. [1] We have indeed a long passage in the works of Sahagun (who lived there from 1529 to 1590) [2] on the latter application which runs as follows:

"There is a great diversity of these cylinders (stalks of reeds filled with sweet-smelling substances, and used as "perfume sticks"). They are prepared from various species of fragrant herbs, finely ground and mixed together, and which, along with other aromatic plants such as bitumen, called *chapopotli*, special varieties of mushroom, the rose known as poyomatli and many others, serve as filling for these cylinders."

What was this chapopotli? It was a bitumen obtained from the sea and in its friable consistency similar to the pitch from Castile. The waves of the sea washed it ashore, particularly on certain days when the moon was waxing. It came in from the sea in a great mass and was collected on the shore by the coast-dwellers. Chapopotli had a sweet scent and was highly prized by the women. When thrown on the fire its pervasive odour filled the air.

There were two varieties of this bitumen. One, mixed in bulk, was generally used for filling the perfumed reed-cylinders. The other was a kind of pitch, called *tzictli* by the women of the region. To make it fit for chewing it was mixed with axin, which made it softer; otherwise the substance would be impossible to chew, as it would break. Bitumen was most commonly chewed by young girls who were not yet fully mature. Some older women also chewed it, but it was not customary for them to do so in public; that was the privilege of unmarried women alone. Married women and widows who indulged in this habit could only do so in their own homes. Those women who had lost all sense of shame chewed it everywhere, in the streets and squares, champing their teeth like castanets. Any respectable women who dared to do the same risked endangering their reputations.

The reason why women chewed tzictli was because it got rid of unpleasant

[1] C. G. Robelo, Diccionario de Aztequismos (Cuernava, Mexico, 1906).

[2] Fray Bernardino de Sahagun, Historia general de las Cosas de Nueva Espana (Florentine Codex) (French transl. by Jourdanet and Simeon, Paris, 1880, pp. 630-631) (modern edition of the General History of the Things of New Spain (Florentine Codex) by A. J. O. Anderson and Ch. E. Dibble, Monographs of the School of American Research, Santa Fé, New Mexico, 1954 No. 14 in 13 parts).

mucus and also prevented bad breath, which would make people shun them. Men also chewed tzictli to remove saliva from their mouths and to keep their teeth in good condition, but they did it in secret. Only those with bad reputations were not ashamed to chew it, and they did so even in public without compunction. Other men who acted in the same way, would naturally get a bad name.

This bitumen was mixed with copal or native incense and sweet-smelling resin, which produced a pleasant fragrance.

What was *axin*? The yellow wax called axin was a pronounced yellow in colour, soft and calefactory. It was prepared from caterpillars, called axquauitl, which lived on trees. Certain flies which fed on the trees laid eggs, out of which these caterpillars grew. They became fatter and fatter as they developed; when they reached their full size the tree was shaken and they were collected. After they had been boiled the axin, now resembling a yellow wax, was squeezed out of them, and stored in corn-cob leaves.

There was one variety called tepetzictli or tacanltzictli, that is to say "wild tzictli". It was chewed like the kind already described, but instead of being black it was as yellow as beeswax. Persons who chewed it did not suffer from headaches, on the contrary, they enjoyed it because they found the taste pleasant. The other variety of tzictli was prepared from chapopotli and tired the jaws of those who chewed it. Tepetzictli was a plant, from the roots of which this bitumen was extracted.

This description shows that asphalt, mixed with other herbs and plant-extracts, was used to make both "perfume sticks" and chewing-gum. The word "tzictli", here explained by Sahagun, must be the same word as we find again in "chicle "or "chicle-gum", used by the Americans for "chewing-gum". One gets the impression that Sahagun was not being very precise in the last paragraph of this extract, and that he was really trying to describe "chicle" in the modern sense of the word, that is, "latex" or the coagulated milky juice of a tropical tree, the Sapota Achras. This juice is obtained in the same way as rubber-latex, and since 1890 ever-increasing quantities of it have been imported into the United States from Mexico and other Central American countries.

Recently Elwes [1] discovered that the Totomacs mined large amounts of Gilsonite near Papantla in the state of Veracruz, even cutting stairways in the Gilsonite. Some of these ancient mines are now covered by as much as ten metres of clay, sand and gravel with no visible entrances. Elwes mentions

[1] G. Sarton, Extensive use of gilsonite by early Mexican Indians (Isis vol. 33, 1941, pp. 58-60). — H. G. Elwes, Extensive use of Gilsonite by early Mexican Indians (Isis vol. 33, 1941, p. 243).

that the thick crude of the seepages is called "chapo" by the Totonacs, who call the Gilsonite (a hard asphaltite) "cóes". This gilsonite of Talaxca is the "only known deposit in all Mexico. The old workings on this single Talaxca vein of gilsonite extend over a distance of at least two miles. Some of these workings are in the form of opencuts, or trenches along the strike of the vein, now partly caved in, whereas others, only found by subterraneous exploration have no apparent exit communicating with the existing surface. The vein at the bottom of this opencut is found completely filling a vertical fissure in conglomerants, and the ancients sank inclined shafts, cutting steps apparently to facilitate carrying the gilsonite up to the surface. In certain cases it looks as if the sand now covering the conglomerate and filling the fissure down to the top of the gilsonite, was deposited after the shafts were sunk and the steps cut.

"In another place of the same vein I sank a shaft about 10 m. in a flat piece of ground, and owing to a slight change in the strike of the vein I missed it by about 1.50 m. There was a long ancient drift full of mud, so that I had to put in bulkheads to prevent this mud continuing to flow into the part of the workings I was cleaning out. To the north the ancients had sunk a "winze" (interior shaft) on the gilsonite vein, also full of mud. In these workings I found pearshaped picks of quartzite with gilsonite adhering to the points, indicating that they had been used to mine the mineral, which is brittle and of hardness 2 on Moh's scale. The top of the vein terminates in a knife edge at, or near the surface of the hard conglomerate. If the ancients found the outcrop of the vein it must have been at the surface of the conglomerate, at least 5 m. below the present ground level, for it is inconceivable that they could have penetrated the extraordinary hard conglomerate with the tools found."

Elwes wonders what the gilsonite was used for and suggests that it may have been diluted with the thick crude from the seepages to give a cement or mortar. However, no such bituminous mortar was ever used by the Aztecs or other Mexican tribes. It might well be the "wild Tzictli" mentioned by Sahagun as this asphaltite has the appearance of copal and other resins. It may have been taken for a resin and therefore used in the manner described above.

However, neither the Mexican oilfields nor the other oilfields in South America added materially to the world oil production until the beginning of the twentieth century.

CHAPTER TWELVE

EX ORIENTE BITUMEN

The fall of the Roman Empire spelt the beginning of a period in which European visitors could visit the seepages of the ancient Near East only with the greatest difficulty. They were exploited locally though perhaps on a more modest level than in antiquity. As the number of pilgrims to the Holy Land increased more and more of them saw the Dead Sea with their own eyes and "the thing called aspatum, as great pieces as a horse" about which Sir John Maundeville told us. However, the most important seepages of this region, the seepages of Hit, were not seen by Europeans for many centuries until rather suddenly a series of visitors such as Cesar Fredericke (1536), John Eldred (1583) and Ralph Fitch (1585) gave detailed reports of their exploitation by the local inhabitants which agree with those found in older Arabic books. [1]

Now we also begin to hear more about new oilfields discovered in the region of the present Baku and in Persia, and though these had little importance for the European oil-supplies until the turn of our century it is worth while reviewing these reports.

First, however, a few words should be said about Arabic terminology of bituminous substances. The usual term for both liquid crude oil and light distillates is "naft", which is equivalent to the classical "naphtha". Crude oil was often distilled and we have excellent descriptions of this operation in Arabic handbooks such as those of Al-Râzî (865-925). [2] He defines distillation (taqtîr) as "an operation like the manufacture of water of roses. It consists in putting the thing into the alembic and lighting a fire under it, so that its "water" ascends in the alembic and flows off to the recipient and collects there". He then proceeds to describe the distillation of naft in these words: "Knead naft to a dough with an equal amount of sal ammoniac and distill. Continue until the distillate is like water and no longer takes fire." Black naft is mixed with white clay or sal ammoniac into a "dough like a thick soup"

[1] R. J. Forbes, Bitumen and Petroleum in Antiquity (Studies in Ancient Technology, vol. I, Leiden, 1955).

[2] J. Ruska, Al-Râzî's Buch Geheimnis der Geheimnisse (Springer, Berlin, 1937).

which is then distilled. Such light distillates or naft are used by Al-Râzî to "soften and loosen the spirits" of solid substances like gems and minerals (borax, malachite, etc.) and he frequently uses "naffâṭa" (oil-lamps) to heat small amounts of chemicals gently, the fuel being either vegetable oils or petroleum.

Al-Râzî already noticed the fact that sulphur was sometimes contaminated with pyrites or naft, and he calls this "black sulphur". Similarly he found that salt was also frequently contaminated by petroleum, which "naphtha-salt" (nâfṭî, milḥ nafṭî) consists of „hard black pieces without lustre and with the smell of naphtha". This is also mentioned by the "Book of Stones of Aristotle" and other authorities. [1] Indeed many Arabic authorities believed that there was some genetic connection between salt and petroleum. Thus the Book of the Foundations of the True Properties of the Remedies, edited about 975, points out that oil-wells often produce salt too. [2] The famous Gershon in the "Second Treatise on the Second Grade which is the Inanimate World" of his handbook discusses salts, vitriols, nitres and petroleum (neft) as a related species of metallic matters. [3]

The current theory of the origin of petroleum was first formulated about 950 by the Ichwân es-Safâ, a secret society of Basra. [4] Water (spirit) and Air (soul) were matured by the action of Fire and produced "fiery sulphur" and "watery mercury". These two secondary elements admixed with more or less Earth and subjected to certain temperatures formed the minerals found in the earth including the bituminous substances such as naft and qîr (asphalt), which, because they had a high air and oil content, were easily liquified and highly inflammable. Al Qazwînî (abt. 1275) gives further details of this theory [5] and describes how the condensation of "mercury" and "sulphur" in the crevices and clefts of the mountains produce naft and qîr like "coagulated dew". This word "qîr" is derived from the Greek "keros" (wax), but in Arabic literature always denotes pitch, tar or bituminous substances like asphalt and asphaltites. In fact even alchemical tracts [6] use the expression "alqîr" for the black colouring substance used at a certain stage to prepare the "Stone". In most cases where the vegetable origin is not clearly indicated

[1] E. Seidel, Mechithar's Trost bei Fiebern (Leipzig, 1908).

[2] Abû Mansûr Muwaffak, Das Buch der pharmakologischen Grundsätze (edit. Achundow, Halle, 1893).

[3] Rabbi Gershon Ben Shlomoh d'Arles, The Gate of Heaven (edit. F. S. Bodenheimer, Kiryath Sepher Ltd., Jerusalem, 1953, p. 122).

[4] Fr. Dieterici, Die Abhandlungen der Ichwân es-Saf·â (Leipzig, 1886, I. 201; V. 87, 107, 116).

[5] Al-Qazwînî, Kosmographie (edit. Ethé, Leipzig, 1868, pp. 385 & 417).

[6] J. Ruska, Tabula Smaragdina (Winter, Heidelberg, 1926, pp. 32 & 234).

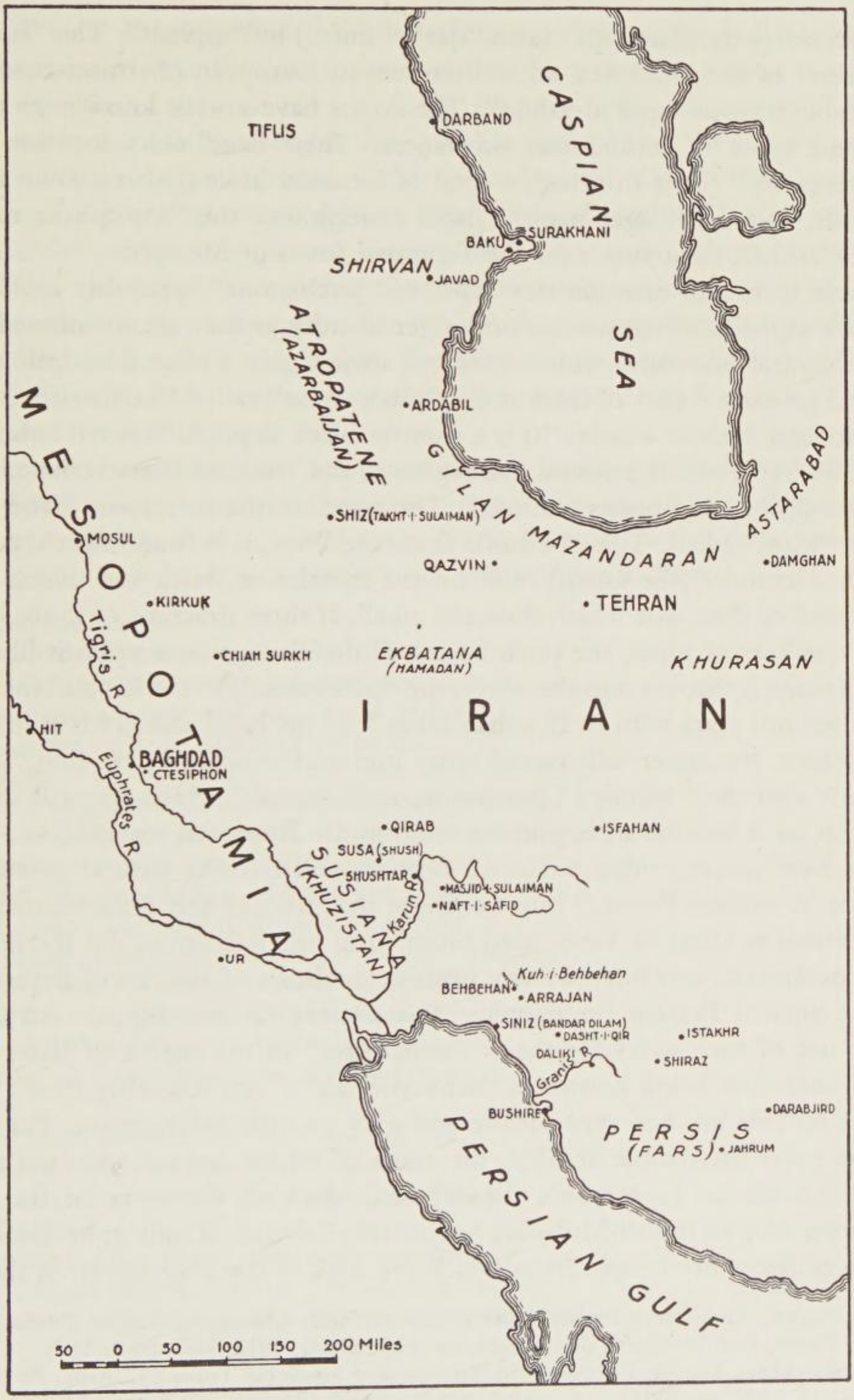


Fig. 22. Map of Ancient Iran.

we can safely translate "qîr" (also "qâr", "kufr") by "asphalt". The "Iudaean bitumen" of the Dead Sea, so well-known to European pharmacists, occurs in Arabic texts as "qafr al-yahûd". The Arabs have a wide knowledge of the different types of bituminous substances. Their handbooks mention [1] the "ḥagar ṭarâqî" (lapis thracius), a kind of bituminous coal also known to the ancients, and the "ḥagar manfî" (lapis memphites), the "memphitic stone", a rock asphalt occurring near the Egyptian town of Memphis.

These texts also mention two types of "pitch-stone", probably asphaltites or rock asphalts which we can no longer identify as they are mentioned only in alchemical literature, which does not always give a clear description of a natural product. [2] One of these is the "pitch-stone" called "ḥagar ziftî" which is described in these words: "It is a stone as black as pitch. When it is broken, it breaks like glass. It is found in a region of the West, its characteristic is that it cures dropsy and opens wounds". The same treatise mentions: "The stone called "ḳîrijj" (qîri): This is a stone from the West, it is found near the town which Alexander (the Great) built on the frontier of Barca and which gives off a kind of dust, but which does not smell. If three drachms of it are mixed with one karr of pitch, the pitch boils and dissolves, it acts upon it like fire. If this stone is thrown into the water, the water receeds to the left and the right and does not react with it. If a man takes it in his hand and holds it in front of his face, the water will receed from him and will not cover him." Then there is also the "mûmiyâ" (ozokerite, rock asphalt) which we will discuss later on, as it became an important drug on the European market.

We have ample evidence that oil deposits and burning natural gases were known in ancient Persia, [3] but we know that neither the Achaemenian nor the Sassanian kings of kings used bitumen in architecture as did the ancient Mesopotamians, nor have we any positive evidence of the use of natural gas in the ancient Persian fire-temples. The ancient fire-worshippers may have made use of such gases for their "eternal fires" in the region of Baku quite early, such fires being known as "achvarishnak" ("not requiring food"). The oldest records are not very precise and give us little information. The ruins of the great fire-temple at Shiz, the ruins of which are now known as the Takht-i-Sulaiman (Solomon's throne) remind us of the story of the Arab historian Mis'ar ibnu'l-Muhalhal [4] who tells us that at this spot there was "a magnificent fire-temple from which the fires of the Magians from the east

[1] A. Siggel, Arabisch-deutsches Wörterbuch der Stoffe (Akademie Verlag, Berlin, 1950).
[2] J. Ruska, Das Steinbuch des Aristoteles (Heidelberg, 1912, Nos. 86 & 168).
[3] L. Lockhart, Iranian Petroleum in Ancient and Medieval Times (J. Instit. Petroleum, vol. XXV, 1939, pp. 1-18).
[4] Muruju'dh-Dhahab, (French edit. by C. Barbier de Meynard and Pavet de Courteille, Paris, 1861-1877, vol. IV, p. 79).

unto the west were supplied. And one of the wonders of this building is that they have burnt (the fires) in it for sevenhundred years and there is no ash whatsoever found in it nor has it ever for one hour been extinguished." However, archaeological research on this spot has proved that the temple, which may date from the period immediately preceding the Christian era, was not built over a place where petroleum gases escaped, and the earlier opinion of Herzfeld [1] was not confirmed. From what we know from later fire-temples petroleum was burnt there rather than natural gases which were apt to soot and to smell evilly, two properties which the fire-worshippers would not have tolerated for their sacred fire. The priests may therefore have collected the "white oil" from seepages near the fire-temples, but we do not know precisely how far back this habit went.

Later poets and historians are apt to project back into the distant past the use of petroleum or naft in their own days. Thus the famous Persian poet Firdausi [2] tells us how Alexander the Great invented a device to scare the war-elephants of the Indian king Porus, whom he calls Fur:

"Then the Shah
Assembled all the master-smiths of Rum,
of Misr, and Pars, twelve hundred men in sum,
Who made a horse, with saddle and with rider
Complete, of iron, fastening the joints
With bolts and rivets. Horse and man were furbished.
They charged it with black naphtha, and then ran it
On wheels before the troops. At sight thereof
Sikander was well pleased for, being wise,
He felt the gain thereof, and bade to make
A thousand such and more: who'er beheld
On chargers dappled, chestnut, black, and grey
An iron host? The matter took the month.
And then the workmen rested from their labours.
Thus led they forth on wheels an iron host
That of all things resembled horsemen most.

Now when Sikander was approaching Fur,
And from afar one host beheld the other,
On both sides rose the shout and dust of battle,
And eager for the fray the warriors
Advanced. They lit the naphtha in the steeds:
Fur's troops were in dismay. The naphtha blazed:
Fur's troops recoiled because those steeds were iron.

[1] E. Herzfeld, Masjid-i-Suleiman (Naft Magazine vol. V, 1929, pp. 5-9).
[2] The Shahnama of Firdausi, (Done into English by A. G. Warner and E. Warner, London 1912, Vol. VI, pp. 115-116).

Whereat the elephants, when their own trunks
Were scorched, fled likewise, and their drivers marvelled.
Thus all the Indian host and all those huge,
High-crested elephants were put to flight."

We are informed by John Hanway [1] that the Persian conqueror Nadir Shah defeated the forces of the Mogul Emperor Muhammad Shah at Karnal in February 1739 by using a similar device (which he had adopted from the Mongol conqueror Tamerlane who also employed such a device against the Indian elephants):

"Caused a number of stages to be made, and fixed across two camels. On these stages he laid naphtha, and a mixture of combustibles, and ordered them to be set on fire. It is well known with what terror these huge animals (elephants) behold this element; so instead of overturning the Persian army, at the approach of the camels the elephants turned about, and put a great part of the Indian army into confusion."

We do not hear definitely about the *oilfields of Baku* (which for a long period belonged to Persia!) until well in the seventh century after the Arabs had invaded and conquered Persia. It is true that the Byzantine authors often refer to their Greek fire as "Median fire", and this may mean that the oil of Baku, or north-western Persia (Media) formed one of its principal constituents. We are also informed that the Byzantine emperor Heraclius when invading Parthia destroyed temples of the fire-worshippers in this region, some of whom burnt natural gases (624 A.D.), but nothing very definite is known about the exploitation of the seepages and gas-wells.

However, we are informed that in 885/886 A.D. the Caliph of Baghdad, al-Mu'tamid, granted the revenues of the naphtha springs and salt-pits to the inhabitants of Darband, [2] but 18 years later Bi Shutur, appointed Governor of Darband, robbed them of these revenues and "being thus deprived of all means, gave themselves up to trade and other employments, and there soon appeared amongst them disorder and corruption". According to the tenth century Hudud al-'Alam (Regions of the World) the province of Qazvin was supplied with oil from Baku.

Al-Mas'udi visited Baku about 915 A.D. and he tells us that: [3]

". . . Vessels sail to Baka (Baku) and (there is there) a spring of white naphtha and other (kinds) and there is not in the world—and Allah is the most knowing—white naphtha except in this spot, and it is (on) the shore of the kingdom of Sharwan

[1] John Hanway's Travels (London, 1753, vol. IV, p. 166).
[2] Darband-Nama or History of Darband translated from a select Turkish version by Mirza A. Kazem Beg, p. 136.
[3] Al-Mas'udi, Muruju'dh-Dahab, Vol. II, ch. xvii, p. 25.

(Shirvan), and in this naphtha-district (Nafata) there are chimneys (i.e. craters or vents) which are sources of the sources of fire which ceases not to burn."

and nearly three centuries later Yaqut (1179-1229) reports the following: [1]

"A town of the neighbourhood of Darband in the district of Shirwan in which is a large naphtha spring; it produces every day one thousand dirhams (drachms), and by its side is another spring from which flows white naphtha like oil of mercury (dahnu'z-zibaq) (and it) ceases not by day or night; its yield is like that of the first (well). And one of the merchants who is worthy of credence informed me that he saw there a bit of land from which fire does not cease issuing forth day and night. I think that a fire has fallen there from some person and that it does not cease because the (combustible) mineral sustains it."

Early in the thirteenth century Ibnu'l-Balkhi informs us that lamp oil of good quality was used in the town of Siniz (Bandar Dilam); it may have come from the seepages of Naft-i-Safid near the northern end of the Persian Gulf, and was later sold as far afield as Isfahan and Tehran. [2] By the end of that century European travellers first saw the springs of Baku. Friar William of Rubruck passed by within a few miles without mentioning them (1254) but the famous Marco Polo who travelled through northern Persia in 1271/3 has the following to report on Baku: [3]

"On the confines (of Armenia) towards Zorziana (Georgia) there is a fountain from which oil springs in great abundance, insomuch that a hundred shiploads might be taken from it at one time. This oil is not good to use with food, but 't is good to burn, and is also used to anoint camels that have the mange. People come from vast distances to fetch it, for in all the countries round about they have no other oil."

An Arab contemporary, Hamdu'llah Mustaufi [4] confirms this:

"There are many springs of this, but the most abundant in this kingdom of Iran is that at Baku. Here over a tract of land they have dug wells to get down to the Naphtha source, and the water which rises in these wells carries the Naphtha on its surface."

We then have to wait nearly two centuries until another Venetian sees the Baku springs, and this is what Giosafo Barbaro has to say: [5]

"Vpon this syde of the sea there is an other citie called Bachu, whereof the sea of Bachu taketh name, neere vnto which citie there is a montaigne that casteth foorthe black oyle, stynkeng horryblye, which they, nevertheless, Vse for furnissheng

[1] Yaqut, Mu'jamu'l-Buldan, Vol. I, p. 477 (edit. F. Wüstenfeld, Leipzig, 1868).
[2] Ibnu'l-Balkhi, Fars-Nama (Cambridge, 1921, p. 150).
[3] Marco Polo's Travels (edit. Dent., London, Book I, cap. iv; Book XI).
[4] Nuzhatu'l Qulub (Transl. Le Strange, London, 1919, pp. 198-199).
[5] Viaggio dello istesso Messer Josaphat Barbaro in Persia (Venetia, 1543, pp. 55-56) (Engl. transl. William Thomas, 1553).

of their lightes and for the anonynteng of their camells twice a yere. For if they were not anoynted they wolde become skabbie."

Early in the nineteenth century a stela was discovered in the Baku oilfields, bearing the following inscription: [1]

"There is no strength and no power save in Allah the most high and the most great. Verily, Allah-Yar discovered and bequeathed this well to the Sayyids (presumably of Darband) in Rabi^{c} II 1003 (December 1594—January 1595)."

which brings up the matter of the ownership of the oil rights. We have seen that under the Abbasid Caliphate the oil rights seem to have been vested in the crown. At some time in the Safavi period (1500-1736) the Shahs converted the rights for the seepages round Masid-i-Suleiman into a waqf or pious bequest for the upkeep of a shrine at Haft Shahidan, a small village of the region. Some members of a family of Sayyids (descendants of the Prophet) of the neighbouring town of Shuster were appointed trustees of these rights and allowed the local tribesmen to exploit the oil and bitumen in return for certain monetary dues. [2] These Sayyids were called the Qiri (bituminous) Sayyids and later exploited the springs themselves, using the proceeds for the upkeep of the above-mentioned shrine.

John Cartwright, an English missionary, visited Baku in 1600, and he gives us a more detailed picture of the oil trade of those days: [3]

"Concerning Bachu, it is a very ancient Hauentowne, very commodiovs for Ships to harbovr in, as also profitable to vent commodities, by reason that Ardouill, Tauris, Eres, Sumachia (Shamakhi) and Derbent, lye not many daies thence. Neere vnto this Towne, is a very strange and wonderfvll Fovntain vnder grovnd, ovt of which there springeth and issveth a maruellous qvantitie of blacke oyle, which serueth all parts of Persia to bvrne in their hovses; and they vsvlly carrie it all over the Covntrey vpon Kine and Asses, whereof yvo shall oftentimes meete three or fovre hvndred in Company."

Geoffrey Duckett [4], a factor to the Muscovy Company, visited Iran in 1574 and used almost the same words as Cartwright.

Olearius (Oelschläger), with the Duke of Holstein's mission at Ardabil in 1637 on his way to Isfahan, saw an elaborate display of fire-works; there were:

"several very excellent and ingenious inventions, as of little Castles, Towrs (sic),

[1] A. Kazem-Beg, Darba-Nama, p. 143.
[2] British Museum Persian Ms. Add. 23534, p. 68.
[3] Observations of Master John Cartwright in his Voyage from Alleppo to Hispaan and back againe (In: Purchas his Pilgrimes, London, 1625, Part II, Book IX, p. 1431).
[4] Geoffrey Ducket, Fift Voiage into Persia (Early Voyages and Travels in Russia and Persia, Hakluyt Society, London, 1886, pp. 439-440).

Squibs, Crackers, etc. In these Fire-works the Persians make use of white Naphtha, which is a kind of Petroleum; but in regard this Drugg is seldome found in Europe, there may used to the same effect, the spirit of Turpentine rectified."

Petroleum in the province of Mazandaran is first mentioned by Sir John Chardin: [1]

" "Petroleum", or "Naphtha", is found in that part of Hyrcania called Mazenderan, in both black and white forms. It is used for varnish, paint, and medecine, and to cure scrofula.

Finally we have in Persia "Oil of Naphtha", which we call "Larme de Mastic", used by the Persians for burning, as well as for paint and varnish in the same way as we do. The best comes from Hyrcania and Northern Media on the edge of the Caspian Sea. This liquid exudes from rocks clear and fluid as water, subsequently thickening, but more or less retaining its whiteness according to the aspect of the rocks from which it emerges; for oil emanating from those facing West and North always remain white, whereas that from rocks facing East or South darkens in time."

From Chardin's time onwards we have a great variety of records of the Baku region, [2] but none of them is as lively as Engelbert Kämpfer's record of 1684 which we shall give in full because of its interesting details on these oilfields which became of such prime importance at the turn of our century. Kämpfer first gives us the story of a ride on horseback through the peninsula of Apscheron near Baku where the oilfields are located:

"The peninsula julting out into the sea towards the south-east is some eighteen kilometres long and some nine wide. It is uniformly level, dotted here and there with small salt-lakes, first of all mountainous in the north-west and some every so often with small hills, particularly at its extremity. The soil is sterile, sometimes loamy, sometimes sandy . . . The northern mountainous part enjoys a better soil and is also arable, particularly in the valleys . . .

We went further and half an hour later came across a piece of land that was on fire; it was covered with a whitish gravel and ash dust. Many flames, wonderful to behold, issued from the numerous cracks. A few cracks were burning fiercely

[1] Sir John Chardin, Voyages de Mr. Chardin (Amsterdam, 1735, Vol. III, pp. 30, 96).

[2] E. Kämpfer, Amoenitates Exoticae (Meyer, Lemgö, 1712, pp. 276-279). — Manucci, Storia do Magor (Edit. Irvine, London, 1907, Vol. I, p. 55). — Hyde, De Veteri Persorum, Medorum ac Parthorum Religione Historia (London, 1760). — Ch. Marvin, The region of eternal fire (London, 1883). — John Bell of Antermony, Travels from St. Petersburg in Russia to Diverse Parts of Asia (London, 1764, Vol. I, p. 47). — Johann Gustav Gärber's Nachrichten von denen an der westlichen Seiten der Caspischen See zwischen Astrachan und dem Flusse Kur befindlichen Völkern und Landschaften und von derselben Zustande in dem Jahre 1728, in Vol. IV, pp. 133-136 of G. F. Müller's Sammlung Russischer Geschichte (St. Petersbourg, 1762) Soimonov's Auszug aus den Tage-Buche des ehmahligen Schif-Hauptmanns und jetzigen Geheimen Raths und Gouverneurs Schiffahrt auf dem Caspischen See, in Vol. VII, pp. 287 and 331-334, of Müller's Sammlung. — Hanway's Travels (London, 1753, Vol. I, pp. 381-84). — Captain Woodroofe's Journal (in Hanway, op. cit., Vol. I, p. 133). — Dr. Cook's Voyages and Travels through the Russian Empire Tartary and part of the Kingdom of Persia (Edinburgh, 1770, Vol. II, p. 382).

and the flames, shooting far out, filled the onlookers with dread; but they all consented to step quite near to the less fierce flames issuing from other cracks. Yet more of them gave off clouds of smoke or vapour which were hardly visible, but from which emanated a very strong smell of naphtha. The wonderful phenomenon extended to over ninety paces in length and twenty-six in width. The cracks were astonishingly small, split open to no more than a hand or foot's width. Some were shorter and semi-circular in shape, others were irregularly curved, as I have drawn on the attached diagram strictly according to nature.

Whenever the dust was removed from the surface of the ground and edges of the cracks, a light and perforated stone, rather like pumice-stone, was revealed, and seemed to consist of shells and minute snail shells.

There we came across ten men or so, occupied in performing various tasks around the fire: some were cooking in copper and clay vessels, placed over one crack that was not burning too fiercely, the mid-day meal for their fellow-lodgers in the neighbouring village Sroganni (Sarachany), which derived its name from this fire. Others were burning lime on stones gathered from elsewhere and heaped together, and then separating the results into heaps which were to be taken away in small boats.

Two Indian fire-worshippers, strangers from the tribe of the Parsees, were sitting quietly within a semi-circular wall which they had built, absorbed in watching and worshipping the fire that was leaping forth, and through which they adored the eternal divinity."

The author is astonished that nobody is set on guard near the seepages for:

"From this naphtha there emanates a fine gas which has the power of causing the flames of a stove or lamp to blaze in no time, and which, once lit, burns away inextinguishably.

After riding for two hours away to the West, we experienced the third memorable occurrence of the peninsula at the source of the black naphtha, extending for a distance of some hundred paces from West to East. The whole of the surface is coloured black by the petroleum which is forced out, as if it were covered with pitch, for when naphtha dries it thickens to a similar consistency. The air is filled with a pungent odour which is offensive and almost unbearable to sensitive noses, even at a considerable distance. Some of the irregularly strewn cavities produce petroleum constantly throughout the year, others remain empty as long as the subterranean supply remains intermittent, yet others serve no purpose through lack of a source. The depth of the cavities extends to thirty ells and over, and at night, not because the veins flowed to this depth but because a hole to a greater depth was used, the petroleum would ooze forth and accumulate, to be collected during the day by the labourers. No special measuring is necessary in excavating because the soil is clayey and firm, and may be dug out without causing danger to those digging even though scaffolding for supporting the walls at any particular depth is dispensed with.

The work of drawing off the liquid is carried out manually by means of leather bottles lowered from above either by hand or by a quite simple winch. Only one particularly rich cavity has a rather large closed shed built over it. It was deeper and wider than the others, and the naphtha flowing forth audibly in a fierce torrent, was drawn off with the aid of a contrivance built over it and set in motion alternately by two horses moving in a circle; here also work was only done for a few hours at night.

The Naphtha was transported in sheepskin containers to the towns of Schamachi and Baku, thence by canal to the whole of Media, and from there on by sea to Hyrcania, Usbek, Circassia, and Dagestan.

It is all used as lamp-oil and as fuel for torches being capable of illumination which surpasses all expectations!

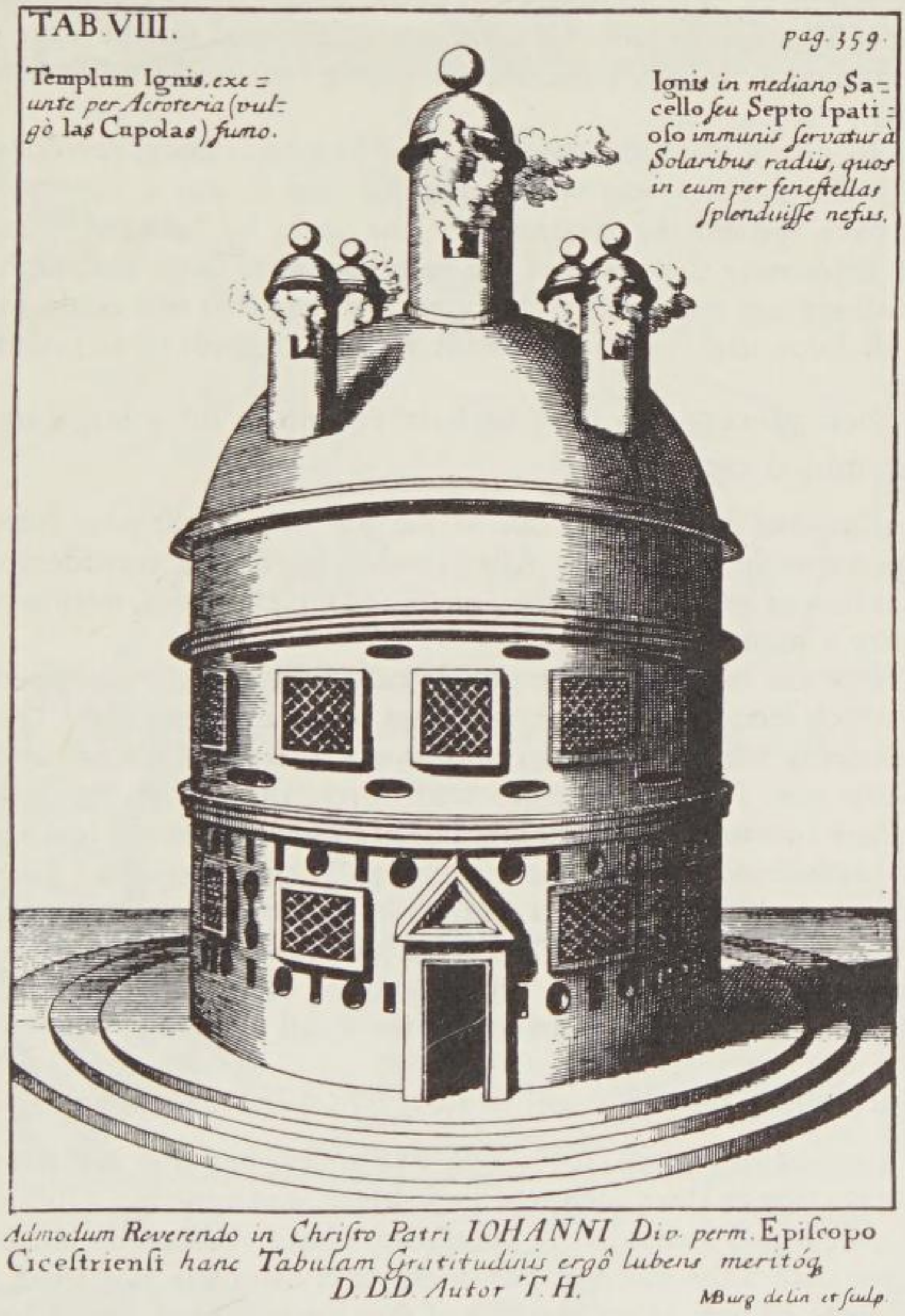

TAB. VIII.
pag. 359
Templum Ignis, exe=
unte per Acroteria (vul=
gò las Cupolas) fumo.
Ignis in mediano Sa=
cello seu Septo spati=
oso immunis servatur à
Solaribus radiis, quos
in eum per fenestellas
splendisse nesus.
Admodum Reverendo in Christo Patri IOHANNI Dio. perm. Episcopo
Cicestrienst hanc Tabulam Gratitudinis ergô lubens meritóq;
D DD Autor T. H.
MBurg delin et sculp.

Fig. 23. A temple of the Fire-Worshippers (After Thomas Hyde, Veterum Persarum . . . 2. edition, London, 1760).

There are twenty-three labourers there daily on the job, all from the nearby village . . .

On the next day, the 8th January, we arose very early and allowed ourselves to be shown a new naphtha phenomenon which they called in their own language the

"naphtha cleansing-place". Not far from our inn, in the same direction as the springs, was a mound like a somewhat flattened hemisphere, no more than five yards high on a largish round base.

On top of it there was a pool some fifty paces in circumference—as far as I could estimate, for the marshy ground and the danger of the edge falling in prevented me from walking around it. Salty-tasting water of a blackish colour was splashing around more as a result of its boiling away in the depths than of its constant bubbling on the surface. This commotion kept visitors spellbound on the edge of the pool, their feet trembling as they felt the depths raging fiersomely in violent movement beneath them.

From time to time a blackish scum of an earthy consistency, revolting to behold, came up with the bubbles; we were informed that it was a naptha secretion. It appeared to have formed the mound over the years by being thrown up against the edges, so explaining the shape of the mass of baked earth and asphalt.

Several small springs surrounded the pond, so large that one could insert a finger or hand. In all I counted twenty-five, with varying degrees of salt content."

Kämpfer then proceeds to give us further details on a large mud volcano which he examined carefully:

"Slimy argillaceous earth oozed out of the top in a continuous but rather slow and hardly perceptable movement. After issuing forth to a considerable height of a few inches it flowed away on one side, unable to contain itself, mostly to the South, as if guided by a natural power . . .

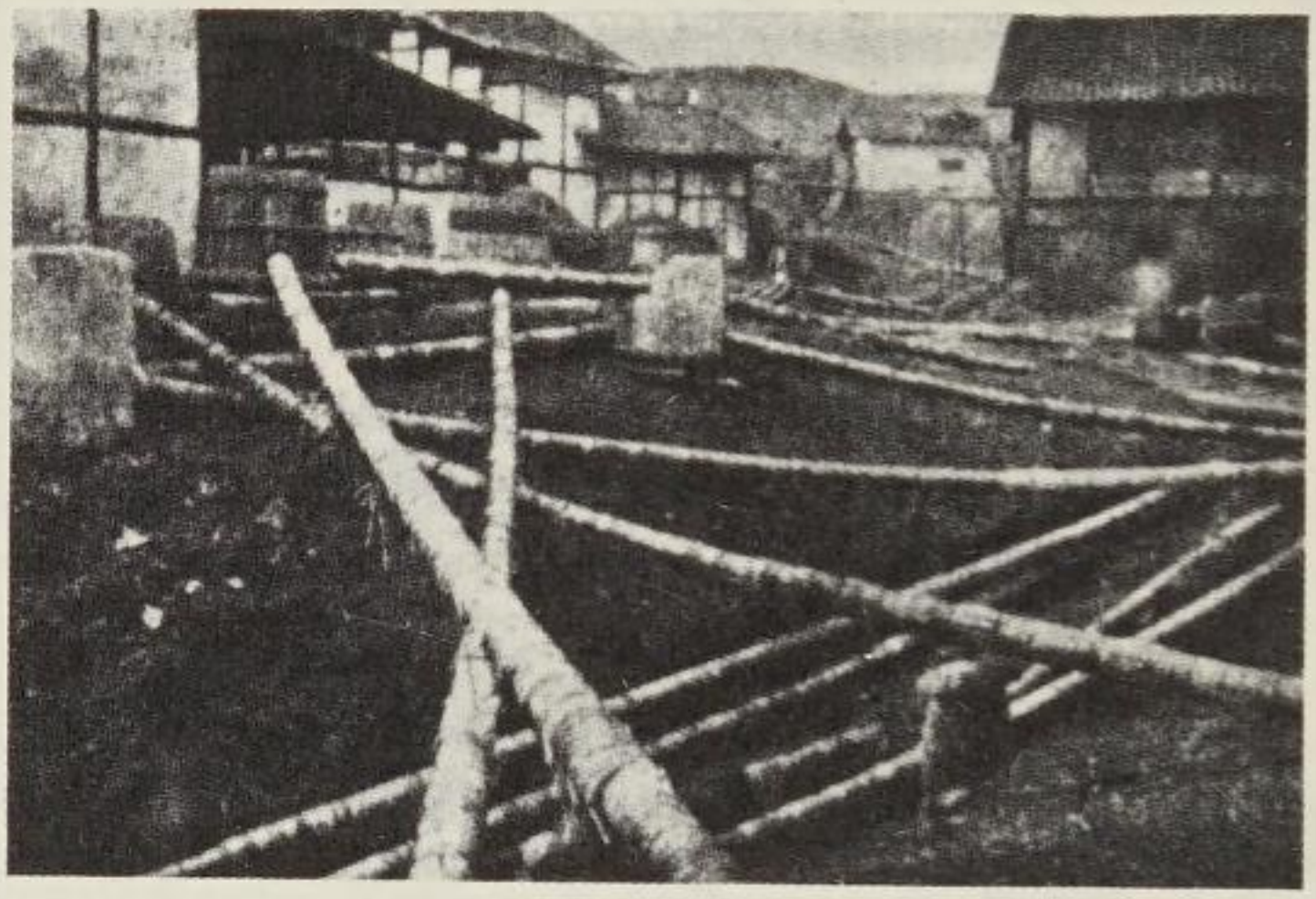
In the distance the hill, which the people called Jugtopa, was shaped like a very high tower, which seemed to consist of a mass of accumulated clay. The inhabitants of the neighbouring village of Sisjaan told how the clay had not always been forced out at the same rate. It often emerged with force, thrown up on high. They had learnt from their ancestors that formerly mighty blocks of stone had appeared with the clods of earth and been cast far and wide. Their village had been threatened with extermination although it lay a quarter of an hour away, with the result that they could not have continued living there in peace had they not appeased the wrath of the subterranean Aeolus, on the advice of a magician, with the blood of a sheep slaughtered before the abysses of the small volcanoe."

Hanway described the Baku oil industry in 1753 in the following words:

"The earth round this place, for above two miles, has this surprizing property, that by taking up two or three inches of the surface, and applying a live coal, the part which is so uncovered, immediately takes fire, almost before the coal touches the earth: the flame makes the soil hot, but does not consume it, nor affect what is near it with any degree of heat. Any quantity of this earth carried to another place does not produce this effect. Not long since eight horses were consumed by this fire, being under a roof where the surface of the ground was turned up, and by some accident took flame.

If a cane or tube, even of paper, be set about 2 inches in the ground, confined and close with earth below, and the top of it touched with a live coal, and blown upon, immediately a flame issues without hurting either the cane or paper, provided the edges be covered with clay; and this method they use for light in their houses, which

The Apscheron peninsula (After E. Kämpfer, Amoenitates Exoticae, Lemgö, 1712, page 271).



Bamboo pipe lines near Tze-liu-tsing.

have only the earth for the floor: three or four of these lighted canes will boil water in a pot; and thus they dress their victuals. The flame may be extinguished in the same manner, as that of spirits of wine. The ground is dry and stony, and the more stony any particular part is, the stronger and clearer is the flame; it smells sulphurous like naptha, but not very offensive.

Lime is burnt to great perfection by means of this phaenomenon; the flame communicating itself to any distance where the earth is uncovered to receive it. The stones must be laid on one another, and in three days the lime is completed. Near this place brimstone is dug, and naphta-springs are found.

The chief place for the black or dark-grey naptha is the small island Wetoy, now uninhabited, except at such times as they take naptha from thence. The Persians load it in bulk in their wretched vessels; so that sometimes the sea is covered with it for leagues together. When the weather is thick and hazy, the springs boil up the higher; and the naptha often takes fire on the surface of the earth, and runs in a flame into the sea, in great quantities, to a distance almost incredible. In clear weather the springs do not boil up above 2 or 3 feet: in boiling over, this oily substance makes so strong a consistency as by degrees almost to close the mouth of the spring; sometimes it is quite closed, and forms hillocks that look as black as pitch; but the spring, which is resisted in one place, breaks out in another. Some of the springs, which have not been long open, form a mouth of 8 or 10 feet diameter.

The people carry the naptha by troughs into pits or reservoirs, drawing it off from one to another, leaving in the first reservoir the water, or the heavier part with which it is mixed when it issues from the spring. It is unpleasant to the smell, and used mostly amongst the poorer sort of the Persians, and other neighbouring people, as we use oil in lamps, or to boil their victuals; but it communicates a disagreeable taste. They find it burn best with a small mixture of ashes: as they find it in great abundance, every family is well supplied. They keep it, at a small distance from their houses, in earthen vessels under ground, to prevent any accident by fire, of which it is extremely susceptible.

There is also a white naptha on the peninsula of Apcheron of a much thinner consistency; but this is found only in small quantities. The Russians drink it both as a cordial and medicine, but it does not intoxicate: if taken internally it is said to be good for the stone, as also for disorders of the breast, and in venereal cases, and sore heads; to both the last the Persians are very subject. Externally applied, it is of great use in scorbutic pains, gouts, cramps, etc. but it must be put to the part affected only; it penetrates instantaneously into the blood, and is apt, for a short time, to create great pain. It has also the property of spirits of wine to take out greazy spots in silks or woollens; but the remedy is worse than the disease; for it leaves an abominable odour. They say it is carried into India as a great rarity, and being prepared as a japan, is the most beautiful and lasting of any that has been yet found. Not far from hence are also springs of hot water, which boil up in the same manner as the naptha, and very thick, being impregnated with a blue clay, but it soon clarifies. Bathing in this warm water is found to strengthen, and procure a good appetite, especially if a small quantity is also drunk."

Shortly after Kämpfer's visit the region of Baku was annexed by Peter the Great (1723), who wished to exploit the seepages for the Russian crown and ordered Matushkin to organize the refining and transport. However, shortly

afterwards Russia had to return its conquest to Persia, which country did not cede the Georgian region definitely to Russia until 1813.

In 1737 Lerche had counted 52 wells at Balachany [1] but in 1829 Alexander von Humboldt reported that there were 82. There slowly grew at Baku a proper petroleum industry. Kokoreff had tried his hand at refining more scientifically in 1859 but the first proper refinery was built by Mirzoeff at Sourachany in 1863, and by 1873 Baku had a total of 23 refineries. The oil industry of Baku became very important when Rakusin discovered the process of making lubricants from the residual "astatki" (later called "mazout") in 1871, and thus supplied Russia with a source of lubricating oils which supplemented the limited amount of vegetable oils available for the purpose.

From the seventeenth century onwards we have ample evidence that petroleum was widely used in Persia as a fuel, and as a solvent for removing spots from textiles, even in the famous lac-manufacture of India. In folk-medicine naft occupied practically the same place as in contemporary Europe, the claims made for petroleum as a drug being practically identical.

If we now turn to the other bituminous substances, we find that the Arab world held a substance called *mûmiya* in high esteem which substance is identified by their physicians with the "pissasphaltos" of the classical pharmacists. [2] This substance was to play a large part in Western pharmacy too until recent times. This word "mummy" bears no relation whatsoever to the ancient Egyptian expressions denoting the dead or embalmed body. It seems that the term mûmiya originally indicated a type of asphaltite or rock-asphalt, which was rather brittle and easily ground into a brownish-black powder. It must have had a rather waxy appearance, for the term mumiya is derived from the Persian "mum" (= wax). The brown powder somewhat ressembled the brown dust into which the mummified bodies of ancient Egypt, filled with spices and resins, crumbled after an exposure of many centuries to the dry heat of the tomb, or the stuff that could be scraped off mummy bandages soaked in resins and spices. [3] Hence we should distinguish between the "natural mumiya" and the "artificial" kind, and we find this distinction made by several Arab and later authors, although they always believe in the efficacy of the drug, whatever its origin.

The word "mumiya" passed into Byzantine Greek as "moumia" or "moumion", thence into Latin (about 1000 A.D.) as "mumia", and eventually into French (momie) and English (mummy), and came to denote the embalmed corpses of the ancient Egyptians, as in the course of time much artificial mumiya

[1] A. F. Büschings Magazin für die neue Historie und Geographie (Hamburg, 1769).
[2] Dioscorides, Materia Medica V. 100; Pliny, Nat. Hist. XXXV, 51.
[3] Sir E. A. Wallis Budge, The Mummy (London, 1925, pp. 201-203).

was taken to satisfy the demand for this drug, which the slender natural sources could not supply.

This mumiya was not prepared by distillation (or inspissation) from the "black naft" which several Arab authors report in Persia, [1] nor from all the different types of bitumen found in that country. [2] The "pissasphaltos" used occurred in a few places only. The earliest reference to the natural mumiya can be found in al-Ishtakhri's "Ways of the Kingdoms", a geographical work of the early tenth century. [3] He stated that it was found in a cave in the side of a mountain near Darabjird in the province of Fars. Its healing powers were so greatly esteemed that a guard was always stationed at this cave, the mumiya was collected in a stone tank and at an appointed time of the year it was collected and taken to the governor of the province. Yaqut, quoting one Muhammed ibn Ahmad of Isfahan, mentions that the rock produced "a liquid like sweat (araq) and from it is obtained white mumiya of good quality and over this cave is a door of iron." [4] These reports seem to refer to a gorge close to the Kuh-i-Behbehan a few miles to the northwest of the ruins of Arrajan.

In the first half of the fourteenth century the geographer Hamdullah Mustaufi of Qazvin [5] mentions not only the mumiya of Arrajan but tells us that there was also a source at the village of Ayi in the district of Shabankara in the province of Fars.

The earliest European visitor to the seepages of mumiya near Jahrum was Sir Thomas Herbert, who was one of the suite of Sir Dodmore Cotton, the English Ambassador to Shah Abbas the Great. He calls it: [6]

"a moist redolent gum . . . sovereign against poison; and (if we may believe them) a catholicon for all sorts of wounds whatsoever, so as when other princes send Shaw-Abbas gold, pearl or like costly presents, he returns them a little of this balsam as a suitable requital."

Some fifty years later Dr. John Fryer [7] gave a more detailed account of the mumiya of the Shiraz district:

[1] P. Schwarz, Iran im Mittelalter (Berlin, 1912, vol. III, p. 116). — M. Nakhai, Le pétrole en Iran (Geuthner, Paris, 1938). — Ibn Hauqal, Travels (edit. De Goeie, Leiden, 1873).

[2] Mehren, Manuel de la Cosmographie du Moyen Age (Kopenhagen, 1874, pp. 69-97, 153).

[3] Abu Ishaq al-Farisi al-Ishtakhri, Masaliku'l-Mamalik (Bibl. Geogr. Arabicorum vol. I, Leiden , pp. 154-155).

[4] Mu'jamu'l-Buldan Vol. I, p. 194 (see also M. Streck, article on Arrajan, Encyclopaedia of Islam, Vol. I, p. 460).

[5] Nuzhatu'l-Qulub, Leiden, 1913, p. 207.

[6] Sir Thomas Herbert, Travels (edit. Sir W. Foster, London, 1928, p. 000.

[7] Dr. John Fryer, A new account of East India and Persia, being nine years travels (1672-1681) (edit. Hakluyt Society, London, vol. II, p. 356 and vol. III, p. 12) (London, 1698, p. 318).

"On the right hand of the King's Highway, between Siras (Shiraz) and Gerom (Jahrum) at Derab, on the side of a Mountain issues the Pissasphaltum of Dioscorides, or Natural Mummy, into a large Stone Tank or Storehouse, sealed with the King's Seal, and that of the Calentures (i.e. Kalantars or mayors) and all the Noblemen of that City, and kept with a constant Watch, till at a stated time of the Year they all repair thither, to open it for the King's use, to prevent its being stolen; which notwithstanding, though it be Death if discovered, yet many Shepherds following their Flocks on these Mountains, by chance light on great Portions of the same Balsam, and offer it to Passengers to Sale, and sometimes play the cheat in adulterating it."

Sir John Chardin mentions [1] that the natural mumiya is "a precious gum which oozes forth from the rocks" in Kirman and Khurasan, Kämpfer was very much interested in mumiya and devoted several pages to this substance. [2] Further deposits of pissasphaltos are reported by Ibn Jubair [3] and other Arab historians, [4] and we have the records of several European travellers [5] who indicate such deposits though they give few details on its exploitation, but wax lyrical over the medicinal properties of mumiya which is "an antidote for poisons, ruptures and broken limbs", and which by this time had become firmly established in Western pharmacology even though serious doubts as to its efficacy had arisen.

At an early date the slender supply from these natural mumiya deposits was supplemented by the brown-black dust taken from excavated mummies, which not only ressembled the mumiya but which, in the minds of the ancient physicians and pharmacists, may have derived further magic potency by being formed from a human body. The two forms, natural and artificial mummy, were universally recognised as equally potent by the Arab physicians. Sometimes the scrapings of mummy bandages were used, sometimes the spices and powdered bones extracted from the corpses. Thus Abd al Latîf tells us that he saw [6] the mumiya which had been taken out of the skulls and stomachs

[1] Sir John Chardin, Voyages de M. Chardin (Amsterdam, 1735, vol. III, pp. 17-18).

[2] E. Kämpfer, Amoenitates Exoticae (Lemgö, 1712, pp. 516-518). — K. Meier-Lemgö & P. M. Edmond Schmitz, Kämpfer und das Persische Bitumen (Bitumen vol. IX, 1939, pp. 49-50).

[3] The Travels of Ibn Jubair (Raḥlat-al-Kinânî) (edit. De Goeie, Gibb Memorial Series, vol. 5, Leiden, 1907).

[4] Paul Schwarz, Iran im Mittelalter (Berlin, 1910, p. 869).

[5] Jean de Thevenot, Suite du voyage au Levant . . . (Paris, 1674, p. 118). — Comte Ferrières Sauveboef, Mémoires Historiques, Politiques et Géographiques des Voyages (Paris, 1790, vol. III, p. 33). — Baron de Bode, Travels in Luristan and Arabistan (London, 1845, vol. I, p. 324). — Stevens, History of Persia (London, 1715, p. 152). — Manucci, Storia do Magor (edit. Irvine, London, 1907, vol. I, p. 55). — Burton, Pilgrimage to El Medinah and Mecca (London, 1893, vol. II, p. 319) (reproducing cap. XIV of the Navigation and Voyages of Ludovicus Vertomannus (1503).)

[6] Abd al-Latif, Relation de l'Egypte (edit. de Sacy, Paris, 1810, p. 273).

of the mummies and sold in town. "I bought three heads filled with it for half an Egyptian dirham. It varies little from mineral pitch for which it can be substituted if one takes the trouble to procure it."

This similarity in appearance is probably the origin of the myth that bitumen was used in mummification in Antiquity, which story originated with Arab authors and still persists in our days. This is for instance, what Ibn al-Baiṭâr [1] tells us: "What I have to say on the subject is as follows. The name mumiya is given to the drug of which mention has just been made (he had quoted a passage of Dioscorides on the pissasphaltos of Albania) and to that which is called Iudaean Bitumen and to the mumiya of the tombs, which is found in great quantities in Egypt, and which is nothing else than a mixture which the Byzantine Greeks used formerly for embalming their dead, in order that their dead bodies might remain in the state in which they were buried and experience neither decay nor change. One also finds certain stones at Sanâ (Yemen) of a dark colour, with a little cavity in which one finds (after having crushed them) a black liquid. They throw the crushed stone into the oil to which this stone yields all its contents of liquid. One finds this liquid in abundance especially in seasons with heavy rainfall". This passage from Ibn al-Baiṭâr is taken over practically unchanged by other Arab physicians and pharmacists or the same story occurs in practically identical words in contemporary and earlier works. [2] The information is taken over by Syrian and Byzantine pharmacologies [3] and the Western authorities base their respect for the drug "mumia" on translations from the Arabic and Greek. In certain cases the mumia is used in Arabic recipes for the preparation of perfumes together with wax as a base for the strong smelling ingredients like musk and amber, [4] but the mumiya "of the mines and of the tombs" is primarily a drug.

What was not known in Europe was that even the supply of mummies soon ran short and that the Jews, who handled the largest portion of this trade, [5] were now obliged to manufacture them. They procured the bodies of all the criminals that were executed in goals, and of people who had died

[1] Ibn al-Baiṭâr, Traité des Simples (edit. Lucien Leclerc, Paris, 1883, vol. III, pp. 346-349, No. 2190; pp. 374-375, No. 2230).

[2] Abdul-Chalig Achundow, Die pharmakologischen Grundsätze des Abu Mansur Muwaffak bin Ali Harawi (Hist. Studien a.d. Pharmakol. Instit. d. Univ. Dorpat, edit. R. Kobert, vol. III, Halle, 1893). — Abd er-Rezzaq ed-Djezaïry, Traité de Matière Médicale Arabe (edit. L. Leclerc, Paris, 1874, p. 535). — H. P. J. Renaud & G. S. Colin, Tuḥfat al-aḥbâb (Glossaire de la matière médicale marocaine, Paris, 1934, No. 263, p. 117).

[3] Epiphanius, Panarion or Medicine Chest (edit. Holl, Leipzig, 1915).

[4] Ya'qûb B. Ishâq al-Kindî, Buch über die Chemie des Parfüms und die Destillationen (edit. K. Garbers, Leipzig, 1948).

[5] T. J. Pettigrew, A History of Egyptian Mummies (London, 1834, pp. 4-11).

in hospitals, Christians and others. They filled the bodies with bitumen from the Dead Sea and stuffed the limbs with the same substance; this done they bound them up tightly and exposed them to the heat of the sun. By this means they made them look like old mummies. In the year 1564 a physician (to the King of Navarre) called Guy de la Fontaine made an attempt to see the stock of the mummies of the chief merchant in mummies at Alexandria, and he discovered that they were made from the bodies of slaves and others who had died from the most loathsome diseases. The traffic in mummies was stopped in a most curious manner. A Jew of Damietta who traded in mummies had a Christian slave who was treated with great harshness by him because he would not consent to become a Jew. Finally, when the ill-treatment became so severe that he could bear it no longer, the slave went to the Pasha and informed him what his master's business was. The Jew was speedily thrown into prison and only obtained his liberty by payment of 300 pieces of gold. Every Jewish trader in mummy was seized by the local governor of the place where he lived, and money was extorted from him. The mummy trade, being hampered by this arbitrary tax, soon languished and finally died out entirely.

However, long before this story of the "mumia falsa" became known some doubts had arisen about the equivalent of the "mumia primaria" (the natural form) and the "mumia secondaria" (the mummy product, which was also called "mumia vera aegyptiaca"). By the end of the fifteenth century Nicolaus Leonicenus of Ferrara, though recognizing the value of mumia primaria and of the "liquor of mumia" prepared from it, began to wonder "why mumia from a dead man's skull was so prized in medicine". He claimed that one who was engaged in the treatment of herbs and natural products should study the soil and fields rather than books and letters. [1] A generation later Brasavola had defined mumia as the remains of an embalmed corpse, and had identified it with Bitumen Iudaeicum. [2] Hence Mundella [3] advised to substitute the natural bitumen or petroleum everywhere for the abominable and detestable mumia in prescriptions.

On the other hand the Paracelsan school [4] still counted mumia amongst the "arcana", the universal medicines, together with laudanum, human blood, balsam and other natural products. One of the members of this school,

[1] Nicolaus Leonicenus, De Plinii et plutium aliorum in medicina erroribus liber (Ferrara, 1492 (1491?), fols. e, i verso - e, iii recto).

[2] Antonius Musa Brasavola, Examen omnium simplicium medicamentorum quorum in officinis usus est (Roma, 1536) (Lyons, 1537, pp. 453-455, 459).

[3] Aloysius Mundella, Annotations (1538, p. 639).

[4] Leo Suavius (Jacques Gohory), Theophrasti Paracelsi philosophiae et medicinae utriusque universae compendium (Paris, 1567, pp. 39-41).

Oswald Croll (1580-1609) even revealed a precious remedy,[1] though he knew that he ran the risk of angering many. This universal medicine was mumia prepared from the corpse of a red-haired man, twenty-four years old, who had suffered a violent death, cut into pieces, sprinkled with powder of myrrh and aloes, soaked in alcohol, suspended in the air and dried; in short, he recommended making the mumia falsa in Europe too. We need not wonder that this Paracelsan doctrine was violently attacked at a very early date. Thus Thomas Liebler or Erastus (1523-1583) in the third volume of his handbook[2] attacks the Paracelsan doctrine and its use of panacea such as balsam, tinctures, mumia, etc.

The doubt as to the efficacy of such a drug, once manifest, became gradually stronger and the natural product itself came to be discredited by the medical profession.[3] However, it takes more than rational proofs and scientific data to eradicate a drug from folk-medicine and even from the pharmacopoeia, and we find mumia in medicine for many a generation after Erastus right into the present century.[4] Hence we need not wonder when we read the following passage entered under *Momie* in the famous Encyclopaedia of Diderot and d'Alembert of 1765:

" "Mummy" also means a kind of drug of viscous composition made up of bitumen and pitch found in the mountains or forests of Arabia, and in other hot Levantine countries; it is used for the embalming of corpses. Dioscorid speaks of a mummy found on the shore near Epidaurus, brought thither by torrents coming down from the Ceraunite mountains, on which they had been dried by the heat of the sun.

Its smell is roughly similar to that of bitumen mixed with pitch. The local people call it "mineral wax". In Latin, or rather in Greek, it is called "pissasphalt"."

Apart from being a drug the Persian mumia was also used as a brown paint since the Middle Ages.[5] Even some fifty years ago one could still read in an up-to-date handbook on paints,[6] that "mummy paint is a brown paint used by artists. Genuine mummy paint should consist of dried ground-up

[1] Osvald Croll, Basilica chymica (Frankfort, 1609, pp. 237-239, 257).

[2] Thomas Liebler, Disputationum de medicina nova P. Paracelsi . . . pars tertia (Basel, 1572, p. 11).

[3] R. James, A Medicinal Dictionary (London, 1743-1745, article Ambra).

[4] Reutter de Rosemont, De la momie ou un médicament démodé (Bull. Soc. Franc. Hist. Médecine, 1912, p. 439). — Lillig, Mumien als Arzneimittel, über Mummifizieren und Konservieren von Leichen (Pharm. Ztg. vol. 80, 1935, No. 34). — W. Proot, Mumia (J. de Pharmacie de Belgique, 1954, pp. 47-53). — Fr. Netolitzky, Vom Asphalt über Mumie zum Ichtyol (Pharm. Zentralhalle vol. 68, 1927, No. 4).

[5] Mss. Thomas de Mayerne, (Br. Museum Sloane No. 2052).

[6] J. Newton Friend, An Introduction to the Chemistry of Paints (Longmans, London, 1910, p. 95).

mummies, mixed with some suitable liquid vehicle such as linseed oil". Fortunately such barbaric destruction of valuable archaeological material is now impossible.

Turning back from this remarkable drug to petroleum, we find in ancient Iran that the seepages reported by classical authors are beyond the river Oxus (in the present Turkoman Republic (U.S.S.R.); they are mentioned again by such Arab authors as al-Mukadassi, Dimashqi and al-Qazwini, [1] some of whom claim that these seepages supplied the whole of Persia with oil, but this claim is unsupported. We find that they were not regularly exploited and European travellers never mention them until the turn of our century.

Modern drilling in Iran began with Messrs. Hotz (1844) and the Persian Bank Mining Rights Corporation (1891-1892) whose work was continued by Mr. D'Arcy and the Concessions Syndicate, and finally by the Anglo-Iranian Petroleum Company.

The local seepages which supplied the bitumen used by the cities of the ancient Indus civilisation seem never to have been forgotten, for Kautilya [2] distinguishes the "burning oil" which floats on the water of many a spring from the thick bitumen which sometimes accompanies it. However, they found only little local application. Either local Indian or perhaps imported Persian bitumen was used to pitch wineskins, for we are informed by European merchants who visited India as early as 1560, [3] that "these are pitched with a bitumen which they call quil, which is like pitch". The local term here referred to is the Tamil and Malay "kîl", Anglo-Indian "kil", the equivalent of the Persian "qir, qil". Indeed in Iran, bitumen was used to pitch the wineskins as early as 1330 when Friar Jordanus reports: [4] "In Persia are some springs from which flows a kind of pitch which is called kic (qir) with which they smear the skins in which wine is carried and stored". This bitumen may have served a twofold purpose in the same way as the pitch used in the Greek amphorae, it may have been intended to make the skin impervious as well as to give the wine a certain flavour which was "à la mode".

More positive information reached Europe about the oil seepages of *Burma*. Their extent was not properly known, but early in the eighteenth century the great Boerhaave tells us that "the Oleum Terrae (earth oil) of

[1] J. Ruska, Das Steinbuch aus der Kosmographie des Zakarijâ ibn Muhammed ibn Mahmûd al-Kazwînî, übersetzt und mit Anmerkungen versehen (Beilage zum Jahresbericht 1895/1896 der prov. Overrealschule Heidelberg, pp. 43-44). — al-Muqadassi, Aḥsan al-taqâsîm (edit. De Goeie, Bibl. geogr. arab. III, Leiden, 1877).

[2] Dr. R. Shamasastry, Kautilya's Arthasâstra (Mysore, 1922, pp. 92, 457 & 461).

[3] E. J. Stanley, The Three Voyages of Vasco da Gama and his Viceroyalty from the Lendas da India of Gaspar Correa (Hakluyt Soc., London, 1869, p. 240).

[4] Friar Jordanus ,Mirabilia Descripta . . . (Hakluyt Soc., London, 1863, p. 10).

India (Burma) is so scarce as to be kept by the Princes of Asia for their own use". [1] Such hear-say news was soon corrected when in 1765 the English Government sent an embassy to the Court of Ava (Burmah). One of its members, Major Symes, visited the seepages of Yenangyoung (Earth-Oil Creek), a tributary of the Irawaddy: [2]

"After passing various lands and villages, we got to Yenangyoung, or Earth-oil Creek, about two hours past noon. We were informed that the celebrated wells of petroleum which supply the whole empire and many parts of India with that useful product, were five miles to the east of this place. The mouth of the creek was crowded with large boats waiting to receive a lading of oil, and pyramids of earthen jars were raised in and around the village, disposed in the same manner as shot and shell are piled in an arsenal. This is inhabited only by potters, who carry on an extensive manufactory, and find full employment. The smell of the oil is extremely offensive. We saw several thousand jars filled with it ranged along the bank; some of these were continually breaking, and the contents, mingling with the sand, formed a very filthy consistence."

These wells 5 miles east of Yenangyoung "supply the whole Empire (of Ava) and many parts of India with that useful product, petroleum." The district of Rainanghong (a name said to signify a "town through which flows a river of earth oil") had 520 active wells in 1797 producing petroleum free from water to an amount equivalent of 400,000 hogsheads. "The mouth of the creek was crowded with large boats waiting to receive a lading of oil, and pyramids of earthen jars were raised in and around the village disposed in the same manner as shot and shell in an arsenal. Walking to the nearest well we found the aperture about 4 feet square, and the sides lined, as far as we could see down, with timber. The oil is drawn up in an iron pot fastened to a rope passed over a wooden cylinder, which revolves on an axis supported by two upright posts. When the pot is filled, two men take hold of the rope by the end and run down a declivity which is cut in the ground, to a distance equivalent to the depth of the well. Thus when they reach the end of the track, the pot is raised to its proper elevation; the contents, water and oil together, are then discharged into a cistern, and the water is afterwards drawn through a hole in the bottom." [2] The oil stood about waist-high in the well, it was of a dirty green colour. In 1858 Yule mentions about 80 wells in an area of half a square mile, which wells varied in depth from 180 to 306 feet.

A generation later Cox [3] visited the same region and in the year 1797 found no less than 520 hand-dug timber-lined wells in production.

[1] H. Boerhaave, Elements of Chemistry (London, 1753, vol. I, p. 117).

[2] M. A. Symes, An Account of an Embassy to the Kingdom of Ava, sent by the Governor-General of India in the year 1795 (3 vols., London, 1800, pp. 261 & 442).

[3] H. Cox, An account of the Petroleum Wells in the Burmese Dominions . . . (Asiatic

"In making a well, the hill is cut down so as to form a square table of fourteen or twenty feet for the crown of the well, and from this table a road is formed, by scraping away an inclined plain for the drawers to descend, in raising the excavated earth from the well, and subsequently the oil. The shaft is sunk of a square form, and lined as the miner proceeds, with squares of Cassia wood staves; these staves are about six feet long, six inches broad, and two thick; are rudely jointed and pinned at right angles to each other, forming a square frame, about four and a half feet in the clear for the uppermost ones, but more contracted below. When the miner has pierced six or more feet of the shaft, a series of these square frames are piled on each other, and regularly added to at top; the whole gradually sinking, as he deepens the shaft, and securing him against the falling in of the sides.

The soil, or strata to be pierced, is nearly such as I have described the cliffs to be on the margin of the river, that is, first, a light sandy loam intermixed with fragments of quartz, silex, etc.; second, a friable sand stone, easily wrought, with thin horizontal strata of a concrete of martial ore, talc and indurated argill (the talc has this singularity, it is denticulated, its lamina being perpendicular to the horizontal lamina of the argill on which it is seated) at from ten or fifteen feet from the surface, and from each other, as there are several of these veins in the great body of free stone. Thirdly, at seventy cubits, more or less, from the surface, and immediately below the free stone, a pale blue argillaceous earth (schistous) impregnated with the petroleum and smelling strongly of it. This they say is very difficult to work, and grows harder as they get deeper, ending in schist or slate, such as found covering veins of coal in Europe, etc. Below this schist at the depth of about 130 cubits is coal. I procured some, intermixed with sulphur and pyrites, which had been taken from a well, deepened a few days before my arrival, but deemed amongst them a rarity, the oil in general flowing at a smaller depth. They were piercing a new well when I was there, had got to the depth of eighty cubits, and expected oil at ten or twenty cubits more.

The machinery used in drawing up the rubbish, and afterwards the oil from the well, is an axle crossing the center of the well, resting on two rude-forked staunchions, with a revolving barrel on its center, like the nave of a wheel, in which is a score for receiving the draw rope; the bucket is of wicker work, covered with dammar, and the labour of the drawers, in general three men, is facilitated by the descent of the inclined plain, as water is drawn from deep wells in the interior of Hindostan.

To receive the oil, one man is stationed at the brink of the well, who empties the bucket into a channel made on the surface of the earth leading to a sunk jar, from whence it is laded into smaller ones, and immediately carried down to the river, either by coolies or on hackeries.

When a well grows dry, they deepen it. They say none are abandoned for barrenness. Even the death of a miner, from mephitic air, does not deter others from persisting in deepening them when dry. Two days before my arrival, a man was suffocated in one of the wells, yet they afterwards renewed their attempts, without further accident. I recommended their trying the air with a candle, etc. but seemingly

Researches, vol. VI, London, 1799, pp. 127-137). — A brief account . . . to which is added an account of the Petroleum Wells in the Burman Dominions (Calcutta, 1826). — John Crawfurd, Account of the Embassy to the Court of Ava in 1826 (London, 1834, vol. I, p. 93; Vol. II, pp. 23 & 206). — H. Yule & T. Oldham, Narrative of Major Phayre's Mission to the Court of Ava . . . (Calcutta, 1856, pp. 19 & 316).

with little effect. The oil is drawn pure from the wells, in the liquid state as used, without variation, but in the cold season it congeals in the open air, and always loses something of its fluidity; the temperature of the wells preserving it in a liquid state fit to be drawn. A man who was lowered into a well of 110 cubits, in my presence, and immediately drawn up, perspired copiously at every pore: unfortunately I had no other means of trying the temperature. The oil is of a dingy green and odorous; it is used for lamps, and boiled with a little dammar (a resin of the country), for painting the timbers of houses, and the bottoms of boats, etc. which it preserves from decay and vermin; its medicinal properties known to the natives is as a lotion in cutaneous eruptions, and as an embrocation in bruises and rheumatic affections.

The property of these wells is in the owners of the soil, natives of the country, and descends to the heirs general as a kind of entailed hereditament, with which it is said government never interferes, and which no distress will induce them to alienate. One family perhaps will possess four or five wells, I heard of none who had more, the generality have less, they are sunk by, and wrought for the proprietors; the cost of sinking a new well is 2000 tecals flowered silver of the country, or 2500 sicca rupees; and the annual average net profit 1000 tecals, or 1250 sicca rupees. The contract price with the miners for sinking a well is as follows: for the first forty cubits they have forty tecals, for the next forty cubits three hundred tecals, and beyond these eighty cubits to the oil they have from thirty to fifty tecals per cubit, according to the depth (the Burmah cubit is nineteen inches English); taking the mean rate of forty tecals per cubit, and one hundred cubits as the general depth at which they come to oil, the remaining twenty cubits will cost 800 tecals, or the whole of the miner's wages for sinking the shaft 1140 tecals; a well of a 100 cubits will require 950 cassia staves, which at five tecals per hundred will cost 47½ tecals. Portage and workmanship, in fitting them, may amount to 100 tecals more; the levelling the hill for the crown of the well, and making the draw road, etc. according to the common rate of labour in the country, will cost about 200 tecals; ropes, etc. and provisions for the workmen, which are supplied by the proprietor when making a new well; expences of propitiatory sacrifices, and perhaps a signiorage fine to government for permission to sink a new well, consume the remaining 512½ tecals; in deepening an old well they make the best bargain in their power with the miners, who rate their demand per cubit according to its depth, and danger from the heats or mephitic air.

From the wells, the oil is carried, in small jars, by cooleys, or on carts, to the river; where it is delivered to the merchant exporter at two tecals per hundred vifs (365 lbs), the value being enhanced three-eighths by the expense and risk of portage, therefore the gross value or profit to the country of the whole, deducting five per cent for wastage, may be stated at 1,081,860 tecals, or 1,362,325 sicca rupees per annum, yielding a direct revenue to the king of 136,232 sicca rupees per annum, and perhaps thrice as much more before it reaches the consumer; besides the benefit the whole country must derive from the productive industry called into action by the constant employment of so large a capital on so gruff an article. There were between seventy and eighty boats, average burden sixty tons each, loading oil at the several wharfs, and others constantly coming and going while I was there. A number of boats and men also find constant employment in providing the pots, etc. for the oil, and the extent of this single branch of internal commerce (for almost the whole is con-

sumed in the country) will serve to give some insight into the internal commerce and resources of the country.

At the wells the price of the oil is seven annas seven pies per 112 lbs. avoirdupois; at the port of Ranghong it is sold at the average rate of three sicca rupees three annas and six pies per cwt. or per hogsheads of sixty-three gallons, weighing 504 lbs. fourteen rupees seven annas nine pies, exclusive of the cask, or per Bengal buzar maund two rupees five annas eight pies, whereas the mustard seed, and other vegetable oils, sell at Ranghong at eleven rupees per buzar maund."

The oil seems to have been used for lamps even in India. We have no idea whether paraffin wax was produced from this crude very rich in wax. As candles were used widely in Buddhist temples, production of paraffin wax seems obvious. Evidently something of the kind existed and the high paraffin wax content of this oil had certainly drawn the attention of European merchants, for we know for certain that Price's Patent Candle Co. made 25 tons of paraffin wax candles in 1857 from wax obtained from imported Burmese petroleum. These imports ceased, however, as the Scottish shale industry produced cheaper paraffin wax and plentiful supplies of cheap paraffin wax from American petroleum became available from 1866 onwards. Only much later was local production of crude oil started on a competitive scale with the first oil-well (1889) and the formation of the Burmah Oil Company.

Exploration and drilling did not start on *Java*, *Sumatra* and *Borneo* before the very end of the nineteenth century. However, seepages on these islands had been known for centuries, as is clear from the term "soeban" (seepage) which occurs in many place-names. When the Portuguese and the Dutch discovered the islands of the archipelago they heard of these seepages. Thus Van Linschoten [1] was the first Dutchman to report that on Sumatra there was a well "which oozes forth pure balm". The sultan of Achin jealously guarded such wells for the petroleum skimmed from their surface had a great tactical value. In Deli (North Sumatra) there was a "well of oil, which they consider inextinguishable, should this oil take flame and burn on the sea." [2] "The King of Achèm used it to set afire two Portuguese galleons against which he waged war some eight or ten years ago in the Straits of Malacca".

We have already mentioned (Chapter VIII) that this "minyak tanah" (oil of earth) had been brought from Sumatra to Holland in 1636, where its medicinal properties were valued as early as 1643. A few decades later we find it on the Italian market in small quantities as a competitor of the Modena oil.

[1] Jan Huygen v. Linschoten, Itinerario . . . near Oost- ofte Portugaels Indien (Amsterdam, 1596, p. 25).

[2] A. de Beaulieu, Rampspoedige Scheepvaart der Franschen naar Oostindien (Amsterdam, 1669, p. 138).

Bontius was the first to give a full report on its qualities. [1] Speaking of the vegetable and mineral oils of the Dutch East Indies he tells us: "We also have a certain noble kind of naphta which is sent over from the island of Sumatra which is right in front of and faces the kingdom of Java, which naphta is called by the Indians "minyak tanah" which actually means "oly der aerden" (earth-oil), for like the bitumen known to us, which we call "peter-olye", it oozes forth from the earth or it flows from rocks into the rivers below. This oil is estimated so highly by the Barbarians that the King of Achin, who is the mightiest ruler of this island has forbidden its export from this island on pain of death. Therefore the inhabitants bring it to us stealthily in the darkest nights when some of our or British ships approach the coast. This oil is rubbed on the bruised parts and soothes the wounded miraculously. However, its smell is heavy though not nauseating". For "lasting diseases" Bontius prefers decoctions of certain plants to the miraculous petroleum. Under the same cover with Bontius' book we find a short compendium for the ship's surgeon written by Verbrugge, which contains a few lines on "mumia" which is swallowed for its "dissolving powers", and an entry on "Oleum Petra" which runs as follows:

"Is very warming, penetrating and digesting. It cures dropsy, vertigo, and cold pains of the nerves and joints."

Most of the later Dutch handbooks contain entries on the petroleum of Sumatra which differ little from the extract of Bontius which we reproduced here. Small consignments of Sumatran oil reached Amsterdam now and then and were sold all over Europe as "minjak tanah" competing with the Modena and Tegernsee oil. Only after important studies and scientific reports [2] had drawn the attention of the Dutch authorities to the importance of these oil seepages did actual exploitation of these oilfields start [3] towards the end of the nineteenth century.

There were no oilfields to be discovered by the earliest European visitors to *China*, for the oil-bearing strata of the province of Szechwan were not

[1] J. Bontius, Histor. Natur. & Medicina Indiae Orientalis (Leiden, 1658, Lib. II, cap. 1). — Oost en West Indische Warande . . . (2. edit. Hayman, Amsterdam, 1734, p. 57). — J. Verbrugge, chirurgijn te Middelburg, Nieuwe Verbeterde Chirurgijnse Scheepskist (Jan ten Hoorn, Amsterdam, 1693, pp. 16 & 35).

[2] W. H. de Greve, Petroleum of aardolie en haar voorkomen in Nederlandsch-Indië (Tijdschr. v. Nijverheid en Landbouw in Ned. Indië, 1865, pp. 281-356). — E.H. von Baumhauer, Over de aardoliën der Nederlandsch-Oost-Indische bezittingen (Versl. Ned. Kon. Acad. d. Wetensch. 2e reeks, Amsterdam, vol. III, 1869, pp. 340-383).

[3] F. C. Gerretson, History of the Royal Dutch (4 vols., Leiden, 1957). — R. J. Forbes, Technical Development of the Royal Dutch/Shell (1890-1940) (Brill, Leiden, 1957).

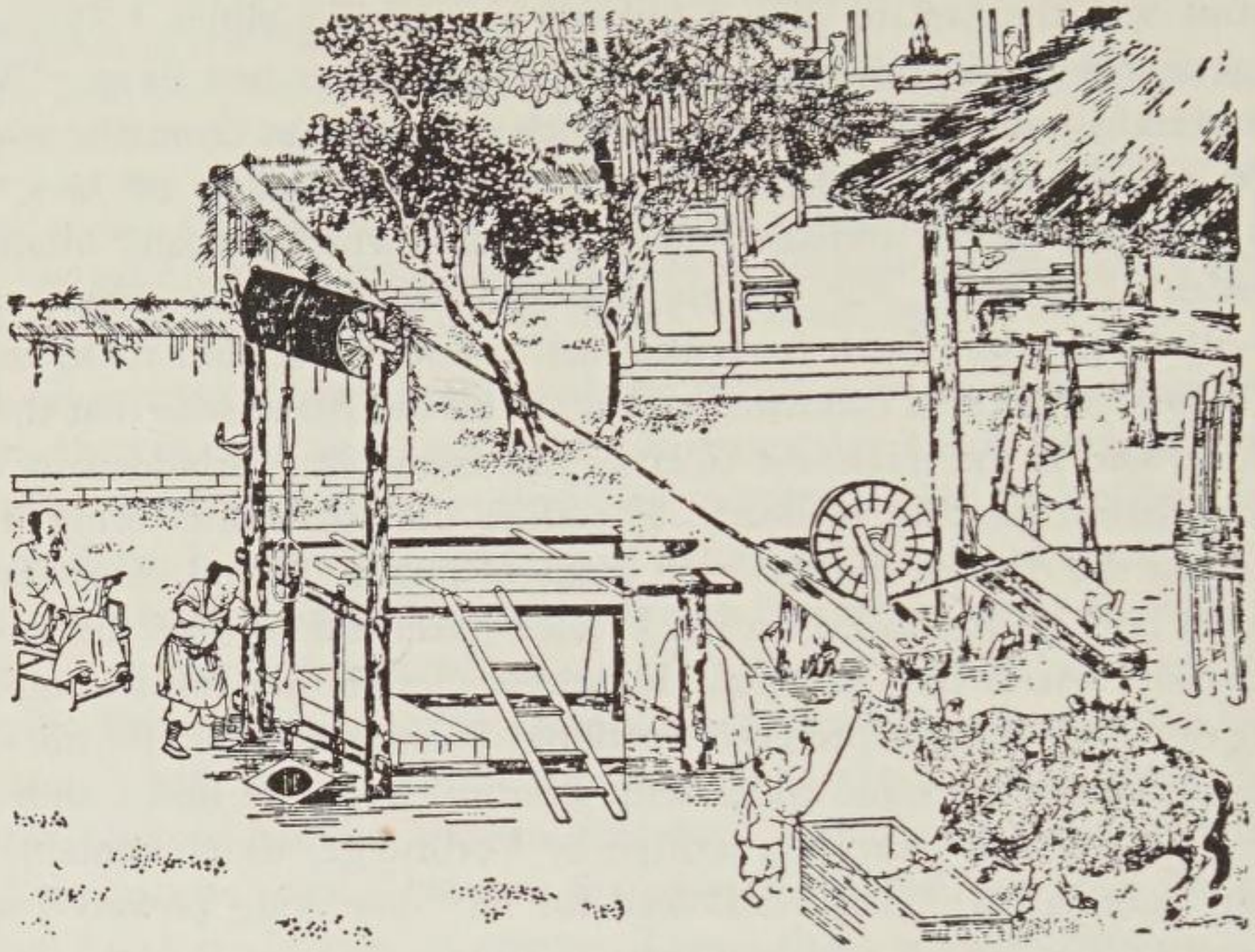


Fig. 24. Drilling a well (Old Chinese print)

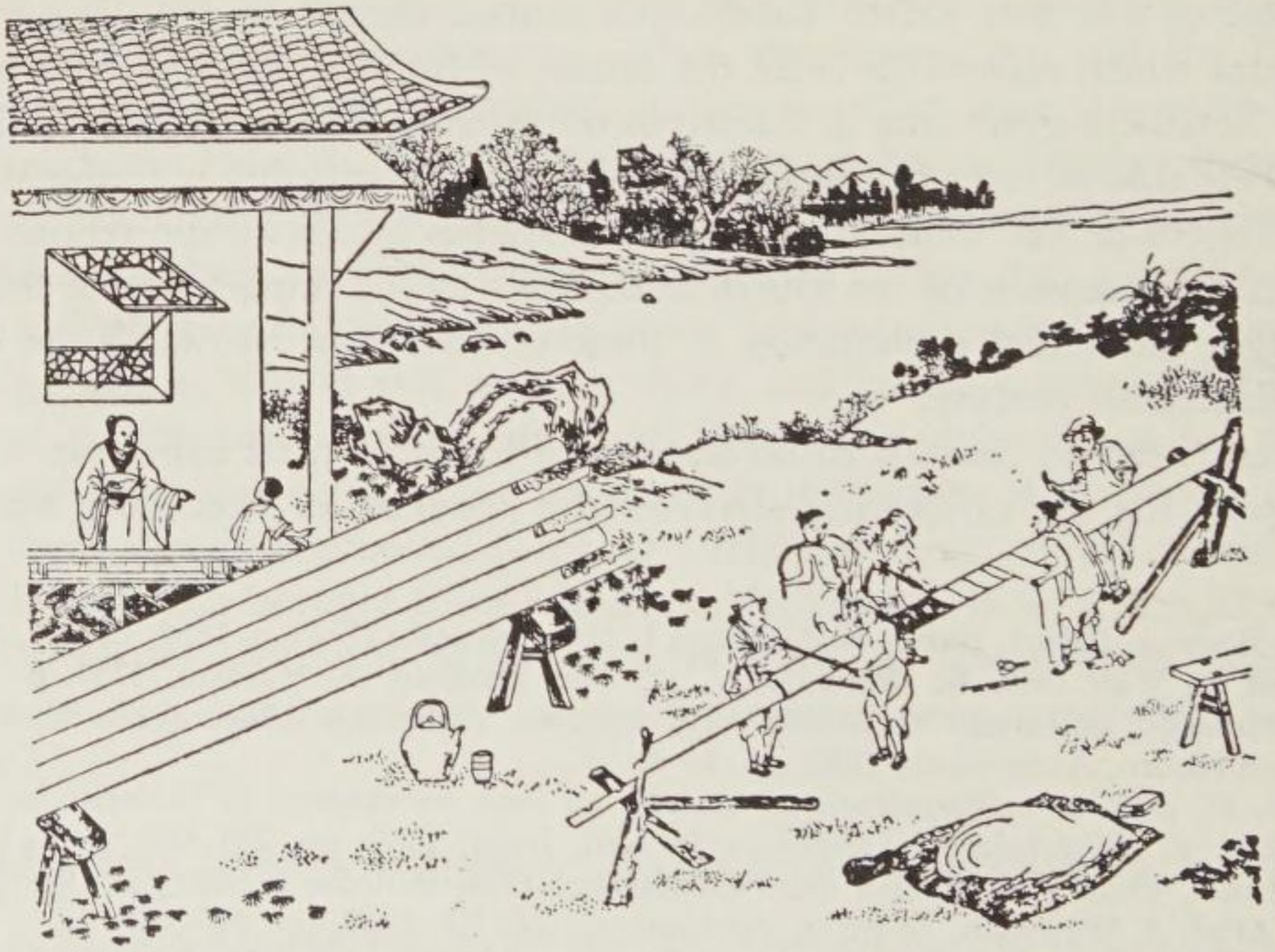


Fig. 25. Making the pipe for the well (Old Chinese print).

explored before the first decade of this century. [1] However, as in the United States of America, oil and petroleum gases were encountered when wells were sunk in this district to tap underground strata of salt and brine. Such salt wells are referred to as early as the Minor Han Dynasty, which lasted from 221 to 263 A.D. In 347 the salt wells of Tze Liu Tsing in Szechwan some 800 feet deep are mentioned, and it is also stated that natural gas was then used for the evaporation of the brine. From 1132 onwards such wells were regularly sunke ven to a depth of 3,000 feet, and this district produced no less than one third of the salt consumed in China in 1911.

The first detailed report of the drilling methods used in this salt production was given by the Apostolic missionary Father Imbert in 1828, [2] and this report had a profound influence on the development of early European drilling methods, as it was soon reproduced in technical journals. As such drilling methods were later applied to oil-wells in Europe it is worth while repeating some of Imbert's remarks. According to his account there were more than ten thousand salt wells in the neighbourhood of Wu Tong Chu in the Szechwan province. Every enterprising business man was engaged in the digging of one or two wells which cost about 1200 Taels (one tael equals one ounce of silver) apiece. The wells pass through rock ranging from 1,000 to 2,000 feet in depth with a diameter of 5 to 6 inches. The drilling is done in the following simple manner: a wooden tube is driven through the surface soil 3 to 4 feet deep; to steady it a heavy hewn stone with a hole large enough for the passage of the tube is set into the surface soil. A large steel percussion bit weighing about 300-400 pounds is used for drilling (fig. 24). The lower end is roughened with incisions and the upper end carries a ring for fastening a rope which suspends the heavy drill from one end of a see-saw lever. On both sides of the other end of the lever, a platform is erected and a lighty clad man jumps from the one platform down upon the free end of the lever and up to the other platform. At each jump, the steel bit is raised about 2 feet and then falls with great force into the hole. From time to time water is poured into the tube in order to moisten the powdered stone. The drill is fastened to a heavy rattan rope, as thick as a finger, and on it between the drill and the see-saw there is a wooden triangle. Each time the percussion bit ascends through motion of the see-saw, an attendant turns the suspension rope with the triangle so that the bit may fall each time with a different contact of its incised cutting surface. There are two shifts of working people in 24 hours.

[1] Kikio Nishizama, Paper on Mines of the Yangtze Valley (J. Soc. Arts, vol. , 1910).

[2] P. Imbert, Über Salzbrunnen in China (Dinglers Polyt. J. vol. XXXIV, 1828, p. 72) (original in Ann. Assoc. Propag. de la Foi vol. III, 1828, p. 369). — Joh. Lotzky, Über artesische Salzbrunnen in China (Dinglers Polyt. J. vol. XXXVIII, 1830, p. 109).

After two inches have been dug, the bit and dirt clinging to it are pulled up, by means of a windlass, the suspension rope being wound upon a drum. The layers through which the hole passes are not always of rock, but sometimes soft carbonaceous earth in which case the drilling becomes difficult or useless, for the hole is then apt to deviate sideways. Usually, however, the holes are vertical and polished as smoothly as glass. If the connection breaks, and the percussion bit drops down it takes from five to six months in order to crush it with the aid of a new drill, and extract the old one piecemeal. Under normal conditions about two feet will be drilled in 24 hours, and altogether it takes at least three years before a well is finished. To raise the brine a bamboo tube about 24 feet long with a valve at the end is lowered down the hole by rope (fig. 27). When it reaches the bottom a strong man grasps the rope and shakes it with his whole weight. The valve is opened by the motion and the bamboo tube filled. Then it is raised with the aid of from two to four oxen or buffaloes. The brine is highly concentrated and on evaporation yields 20-25% of salt.

Inflammable gases escape from some of these wells. If a torch is brought to the mouth of the well, the gas ignites and throws up a flame twenty to thirty feet high. This property has been put to good account and the wells thus utilized are called fire wells. The mouth of such a well is closed with a small bamboo tube, and the gas led off as needed. At the mouth of the tube the gas may be ignited with a candle without danger of setting fire to the bamboo. The flame is blueish, 3 to 4 inches long by one inch in diameter. It can be extinguished by placing a piece of clay over the opening or by blowing it out.

Near Tze Liu Tsing, forty hours from the first-named town, gas issues in sufficiently large quantities from the wells to be used for fuel in the evaporation of the brine. In one valley there are four wells originally drilled for brine. The brine gave out, and in the attempt to drill deeper a level was struck from which issued a black inflammable gas. To protect these wells from fire their mouths are surrounded with a wall 6 to 7 feet high. Surrounding this wall are four halls which contain the evaporation pans. In August, 1826, one of the wells caught fire accidentally. There was a thunderlike report and immediately the whole enclosure was a mass of flame which swayed about two feet above the well. Four labourers brought a heavy stone to cover up the well, but it was thrown high up into the air. Nothing daunted, the Chinese found another expedient and collected a large amount of water, high up on the mountainside. This water was all at once released on to the well, and the flame was extinguished.

A bamboo pipe is inserted into the well a foot below ground level on all four sides, to tap the gas and lead it to the 300 evaporation pans now in use.

Each flame has its own pipe which is fitted as a burner with a 6-inch long clay pipe one inch in diameter. Other pipes are led along the walls terminating in jets above the pans to illuminate the building. The unused balance of the gas is led away outside the buildings and burns there in three large flames about two feet high and thus regulates the pressure of the gas which is used for heating and lighting.

According to modern reports a wooden well-head was built at the mouth of the gas-wells, about ten feet wide and ten feet deep, from the side of which a bamboo pipe led away as far as ten li ($3\frac{1}{4}$ miles) to the evaporating room. The gas escapes into the upper part of the stove from a hole as big as one's finger above which the salt pan was placed. When lit the gas flame was bright and two or three inches long. The surplus gas is conducted for many miles to the salt wells in Kia-ting-fu where it is also used for heating and lighting.

A modern Chinese authority [1] informs us on the drilling equipment used.

"The work of boring was very difficult and a great number of devices were used to overcome the numerous obstacles encountered. The tool used for drilling was a chisel-shaped piece of iron, seven or eight feet long and weighing more than one hundred catties (pounds), the cutting edge of which was about one foot wide and two and a half inches thick, resembling the tail of a fish and therefore called a "fish-tail" chisel. This chisel was attached to a length of bamboo which, in turn, was fastened to an iron ring, tied to a rope which passed over a pulley at the top (fig. 24).

During the drilling the whole apparatus was operated by men or oxen, making a downward stroke to the earth, capable of boring more than one foot every day and night. When the operation has been carried on to a depth of more than three hundred feet, the drilled well was lined with wood in order to exclude the water from the overlying strata. This wooden lining was made of upright and round fir timbers, each about ten feet long, cut vertically into two halves and having the central portion removed. Each length was attached to the next with proper connections and was wrapped round with cloth, flax, tung-oil, lime, etc. to make it water-tight and suitable for the purpose. More than twenty of these lengths of fir were required for each well (fig. 25). After the wooden lining had been set in place, a small tool was used for boring. The cutting edge was like a silver-ingot and so derived its name "silver-ingot chisel". During this stage of drilling, lasting a very long time, several years, sometimes more than ten, were required, and many difficulties encountered.

It was necessary to remove the mud and splinters of rock at frequent intervals. This was done by the "sand pump" which was a long bamboo pipe, bound up strongly with flax thread, carrying a valve at its bottom end. It was tied to the bamboo in place of the "fish-tail chisel" and lowered to the bottom of the well. The water, which was always present or introduced into the well if required, rushed into the pipe, drawing the débris with it; then the valve was closed and the tool was at once raised. Boring continued after each of these operations.

When the earth was bored to the depth of more than 1,200 feet, the "yellow

[1] Li Ch'iao-p'ing, The chemical arts of old China (Easton (Pa.), 1948, pp. 61-64).

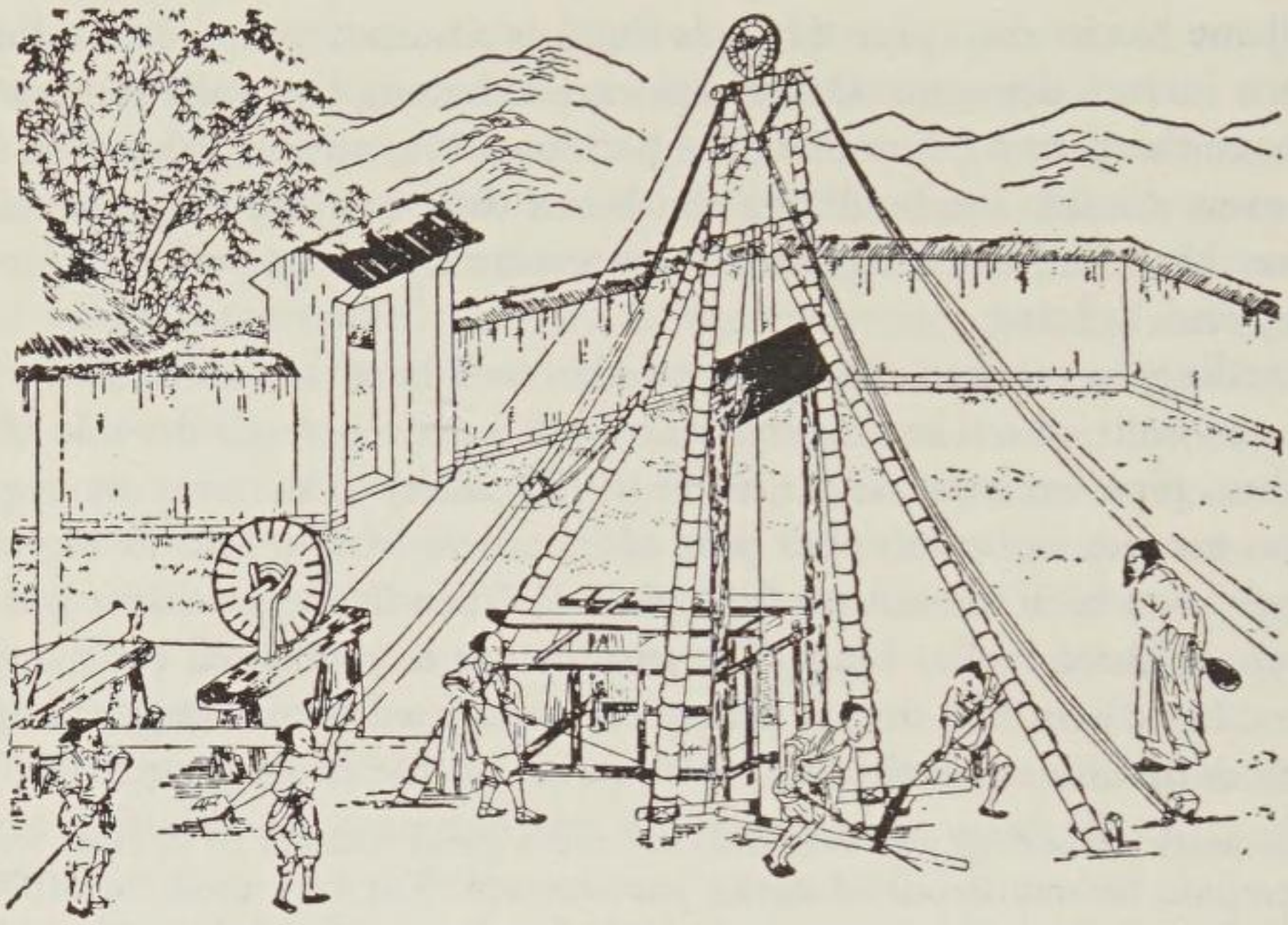


Fig. 26. Sinking the bamboo casing (Old Chinese print).

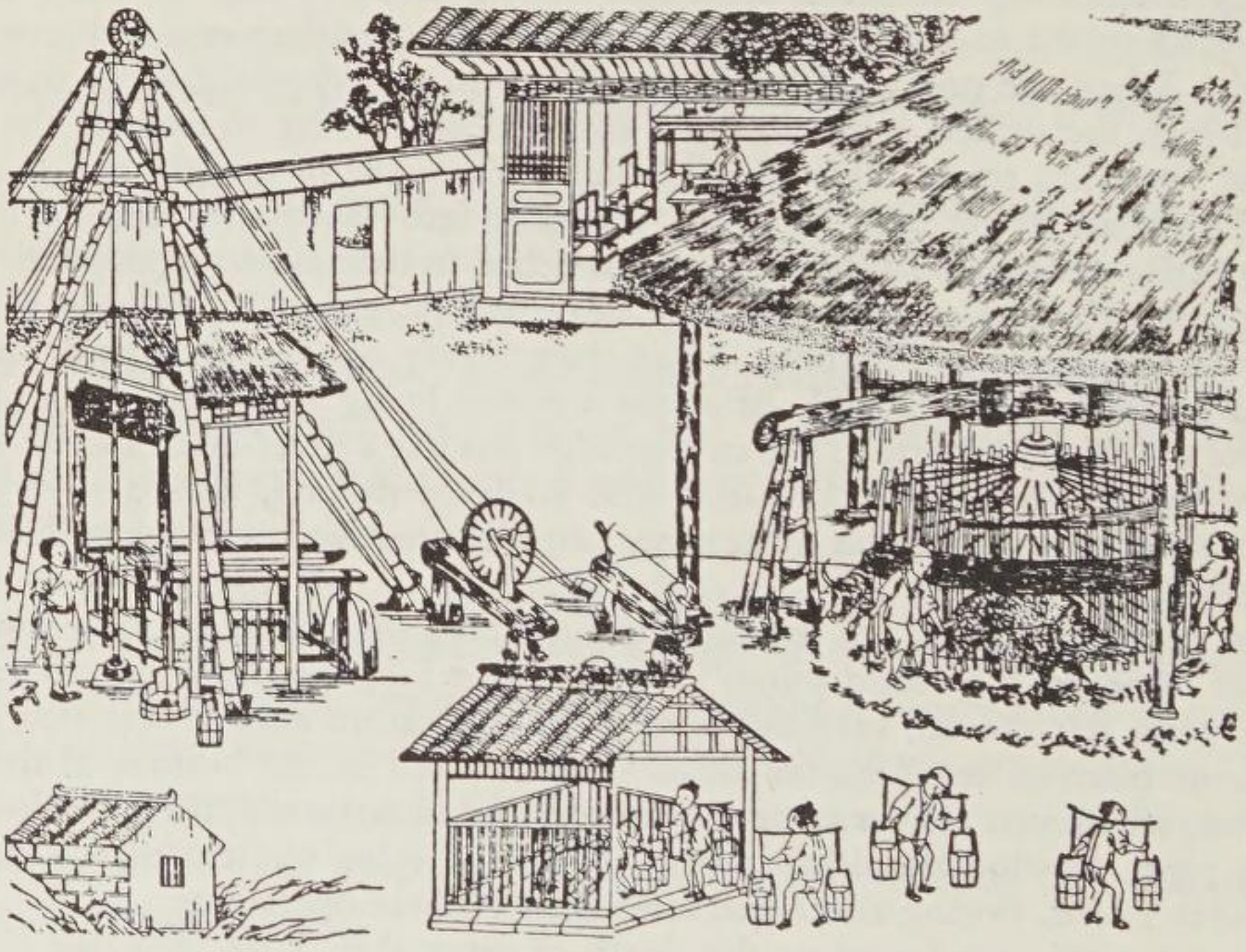


Fig. 27. Pumping the brine (Old Chinese print).

brine" was found and below 2,500 feet, the "black brine", the latter containing more salt."

Alexander Hosie, a keen observer whose travels in Szechwan extended over the years 1882, 1883 and 1884, reports in detail on the production of the brine [1] (fig. 27):

"At the salt wells of Tsu-liu-ching, Szechwan, a square stone embedded in the ground has a central hole a few feet in diameter. I found a hempen rope issuing from the hole, about one inch thick, which passed over a moveable pulley wheel, fixed at the top of a staging some 60 feet high, and bearing a striking resemblance to the shears at a dockyard. The rope from the pulley wheel led to another wheel, fixed nearby, a few feet above the ground. Passing over this latter wheel it entered a large shed, the floor of which was several feet underground. In the centre of this shed was an enormous horizontal bamboo wheel or drum, 12 feet in height and 60 in circumference, placed on a vertical axis, to which the rope above-mentioned was attached, six feet from the ground.

Now to return to the well. The other end of the rope descended from the first pulley wheel directly into the well. It was just being pulled up and after the lapse of a quarter of an hour, the top of the tube, from 9 to 10 inches in circumference, attached to the rope made its appearance and was drawn up to within a foot of the wheel. In the meantime a workman, stationed at the mouth of the well, had thrown a rope around the tube, which was composed of the stems of a number of bamboo fixed together, and as soon as its lower end appeared, he drew it one side and over a wooden reservoir built into the ground. Embracing the tube with his left arm, he plunged an iron rod which he held in his right arm, upward into the bottom, and raising a leather valve fitted there, allowed the contents, consisting of black dirty-looking water, to escape into the reservoir. This was the brine. The tube was again placed over the well and descended with great rapidity, after which it was again pulled up.

As the drum revolved, the rope coiled around it at sufficient height above the ground not to impede the buffaloes. For a quarter of an hour, that is, until the tube has been raised up from the well, the animals were driven around at a trot by the four drivers, after which the poor beasts, exhausted and white with froth, were unharnessed, and led back to their stable, whence a fresh relay was brought. When the animals were unharnessed and the signal given, the drum reversed with great velocity, creating a violent wind all around until the tube had again descended to the bottom of the well. Forty animals were employed at this well, and each relay raised the brine about ten times in every 24 hours. From the chief large outside reservoir, the brine was carried off in bamboo pipes laid down between it and smaller wooden reservoirs which received it in the evaporating sheds."

We are told that in certain cases oil floated on top of the brine, which was then run slowly through three reservoirs from which the oil was skimmed to be sold as an illuminant in primitive lamps.

The majority of *the Japanese oilfields* are to be found on the inner rim of the

[1] Alexander Hosie, Three years in Western China (London, 1890).

Japanese archipelago, on the west coast of Japan facing the mainland of Asia. They are mostly of Tertiary origin. [1] The first gusher was drilled there in 1891 by the Nippon Petroleum Company, but many centuries earlier the seepages in the region of Echigo had been tapped. [2] "It is said that the oldest wells of Echigo were near Kusodzu, and they are supposed by the inhabitants to have been dug several hundred years ago. It is said in the Japanese history called Kokushiriyaku (I am told) that rock oil or "burning water" was found in Echigo in the reign of Tenjitenno, which was 1260 years ago and about 615; and that was probably at Kusodzo, where there are still very old natural exposures as well as dug wells. The name of the place, Kusodzo, is the name given in the country to rock oil, and means "stinking water"; and the very fact that the word is by contraction so much changed from its original form, kusai midzu, shows of itself considerable antiquity. Natural gas even is called kazakusodzu, the first two syllables meaning wind or air, and evidently identical etymologically with our very modern western word gas, which is at any rate clearly identical in its turn with the German word Geist and the English ghost—spirit, the Latin spiritus, breath, breeze or essence."

We are further informed [3] that "in A.D. 668, petroleum and asphaltic substances were offered to the Court of the Emperor Tenji from the province of Echigo . . . and that the zeal of the Emperor Mommu for mining industry was so intense that he took the initiative for the issuing of the mining law, which is known in the famous code Taihorei, issued in June 701". Some nine centuries later (1613) there was a project for the utilisation of the natural gas from the oilfields of Garameki village (Kanbara County, Echigo). The great changes came early in the nineteenth century:

"Petroleum in Echigo was formerly obtained from ditches excavated along the outcrop, as seen at Kurokawa, which was, however, changed in 1818 to the pit-sinking method. The primitive method of the hand-dug wells had been used everywhere and particularly the two following methods, which are called "Tebori" and "Kadzusabori".

"Tebori" or hand-dug well is a primitive method, sinking a square pit 4 to 6 feet in width. This well is used in such places where oil-bearing beds are very shallow, where thin oil yielding layers exist, or where the surface water is rare. The depth of wells of this kind is less than 600 feet, and it is commonly found to be very difficult to work them deeper.

"Kadzusabori" is an improved Chinese method of boring which is worked by

[1] G. Kobayaochi, Geology of the Oil Fields in Japan (Economic Geology vol. XX, 1925, p. 83 ff.).

[2] B. Smith Lyman, First Report of Progress, Geological Surveys of the Oil Lands of Japan (London, 1877, pp. 17-35).

[3] Mining in Japan, Past and Present (Bureau of Mines, Dept. of Agriculture and Commerce of Japan, 1909).

human labour only, without any aid from a machine. The derrick for this well is 30 feet in height. The characteristic points of this well are as follows: a bamboo pole is employed instead of the working beam, its elasticity being utilised in drilling the well. The split bamboo, joined to the required length, is also used instead of both the drilling cable and the sand line. One end of the bamboo rope is wound to the wooden wheel from 12 to 18 feet in diameter, which is turned by three workmen, and by the rotation of which the drilling tool or the sand-pump joined to the other end may be let down the well or raised up to the surface."

On the favourable condition of the strata, the depth of this well may be carried down to 1,000 feet. Although this process needs much time for the work of boring, it is still used now on account of the fact that its arrangement is very simple and its expense is comparatively small. On the average, the number of workmen employed are four in the Tebori and five in the Kadzu-sabori, while the American rope drilling system needs at least eight workmen. The American rope drilling was first put into practical operation in 1890, at the Amaze district in Echigo province, and as a result, a gusher was struck at the beginning of the following year.

In 1877, the year in which Lyman published his report "reviewing all the Echigo oilfields we find that there are in all 522 productive wells, of which the deepest is 122 fathoms (732 feet) deep; and the greatest yield is about 1.2 barrels (koku) a day; and the total yield about 26 barrels . . .; giving an average of about two gallons (5 shô) a day for each well. In Shinano, on the other hand, the yield is still far smaller. There are in this province, in spite of the numerous traces of oil and gas, only 22 productive wells, of which the deepest is 57 fathoms deep, and the best has a yield of 2½ barrels a day. The total yield is little over 5 barrels a day, or an average of 9½ gallons (23.3 shô) to each well. The whole yield of the two provinces then is about equal to that of two average oil wells of Pennsylvania". No Japanese oil found its way to European markets in these early days.

CHAPTER THIRTEEN

OUT OF STONES OIL FOR LAMPS

During many centuries oil had been produced from bituminous rocks and sands by washing or smelting processes but only rarely was oil produced by the dry distillation of shales as in the case of the Dirschoel of Seefeld (Tyrol). The rise of the shale-oil industry coincides with the earlier half of the nineteenth century and it is intimately connected with the revolution in lighting which took place during that period.

This revolution began when in 1784 Francois Pierre Ami Argand (1750-1803) demonstrated to the Royal Society of London his oil lamp with a circular tubular wick, allowing an air supply to the inner and the outer surfaces of the flame, the oil being supplied to the wick by gravity from a reservoir at a higher level than the burner, the flame being protected by a cylindrical glass chimney. This earliest oil lamp was soon (1785) perfected by the French pharmacist Quinquet, whose name the oil lamps of Paris bore from 1789 onwards. Watchmakers like Carcel (1800) and others perfected the system of supplying the wick with oil by putting pressure on the oil surface in the reservoir by means of springs, etc. and thus they did away with the awkward high position of the original Argand reservoir which intercepted much of the light. [1]

The birth of the modern oil lamp coincided with the rise of the gas industry. Lebon and others had tested many materials for the production of gas by dry distillation and the distillates obtained from such materials as wood, peat, coal and shales provided the chemists with a host of new chemicals and distillates which could be applied as illuminants apart from the gas produced. Thus paraffin wax had been discovered in Rangoon oil by Christison of Edinburgh about 1830. [2] He called it "petroline" and it proved identical with the "paraffin" prepared by Von Reichenbach when subjecting wood to

[1] F. W. Robins, The story of the lamp and the candle (Oxford University Press, London, 1939). — Werner Bloch, Vom Kienspan bis zum künstlichen Tageslichte (Dieck & Co., Stuttgart, 1925).

[2] R. Christison, Trans. R. Soc. Edinburgh, vol. XIII, 1836, p. 118.

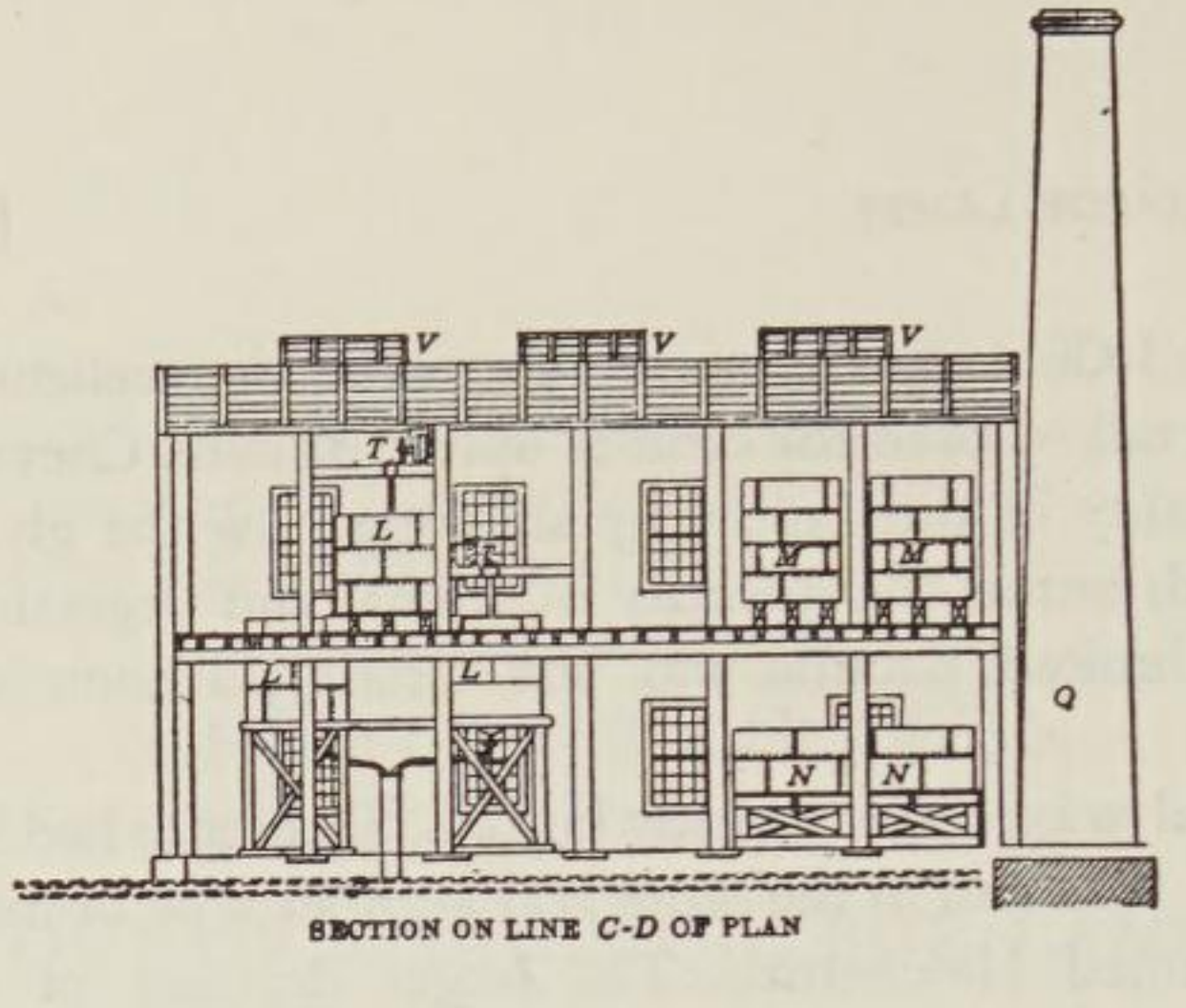
dry distillation in 1830.[1] This substance provided an excellent admixture and substitute for the tallow used for candles upto that date. Chevreuil had indeed improved the quality of this tallow by showing how the glycerine could be properly removed, but as the quantity of animal and vegetable fats available for lighting was limited, paraffin wax was certainly a boon to candle manufacturers.

Natural mineral waxes were already known. Sheererite had been discovered in Switzerland in 1822 and in the same year another type of mineral wax from Scotland was named Hatchettite. The larger deposits of ozokerite were discovered near Slanik (Moldavia) by Glocker in 1833.[2] As the supply of animal (whale oil) and vegetable (castor or linseed oil) oils was also limited, the hunt for materials yielding good "photogen" distillates for oil lamps and/or paraffin wax for candles was on. As the crude oils washed and smelted from bituminous rocks were usually very heavy and viscous they seemed of little use for lighting except for local use in primitive lamps.

Thus the urge to find good materials for gas production and the manufacture of lamp oil and paraffin wax stimulated the study of the oil shales, which had been known for many centuries. Shortly after Von Reichenbach's discovery two industrialists from Dijon, Blum and Moneuse, started research on the production of lamp oil from shale at Epinac, on the border of the Autun oil shale deposits (Saone et Loire). In November 1832 they obtained a patent[3] for the "application of mineral oils obtained by distillation for lighting purposes by suitable means and using lamps particularly suited for this purpose." The inventors describe how "having obtained by distillation in closed vessels an impure oil, this is treated with one twentieth or more parts of sulphuric acid. The mixing having been effected at ordinary temperature, the sludge separates easily and precipitates on the bottom of the vessel after a shorter or longer stretch of time. We then wash the oil to remove the acid and complete this separation by the addition of chalk or lime. We then filter the oil, which is thus decolorised and smells much less than the original impure oil. We then redistil it and if we desire to obtain a white oil, the oil-fractions which are uncoloured are collected though they may trail along mechanically a small amount of lime and even particles of sulphuric acid which seem to play an indifferent part during this operation."

However, Blum and Moneuse never got beyond the semi-technical stage

[1] Carl von Reichenbach, J. Chemie und Physik, vol. II, 1830, p. 486.
[2] Glocker, Schweiz. Apoth. Z. vol. 69, 1833, p. 215.
[3] French patent No. 5104 of November 17, 1832 (Descriptions des machines et procédés pour lesquels des brevets d'invention ont été pris sous le régime de la loi du 5 juillet 1844, Tome LXV, pp. 250-251, Paris, 1847).



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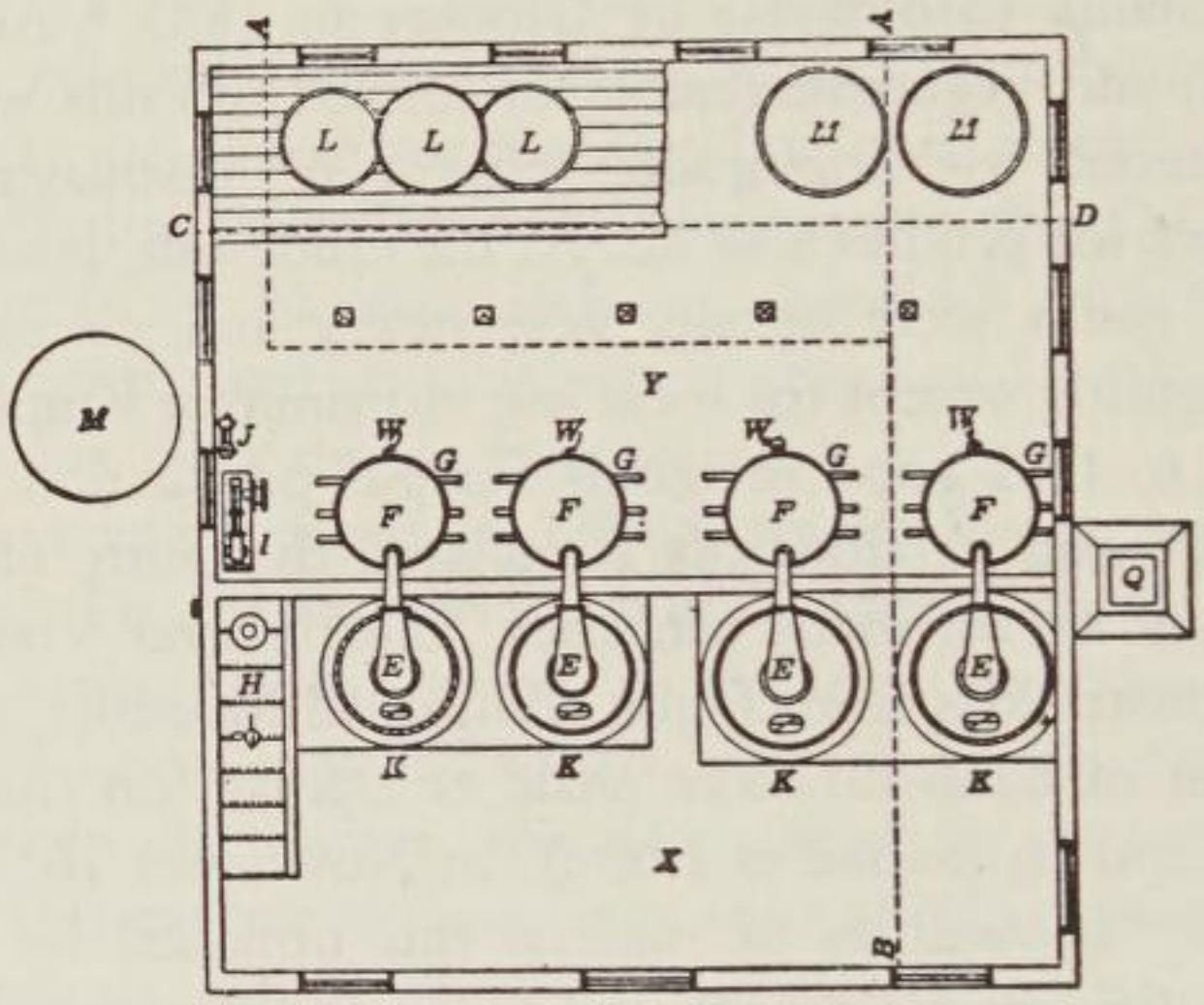


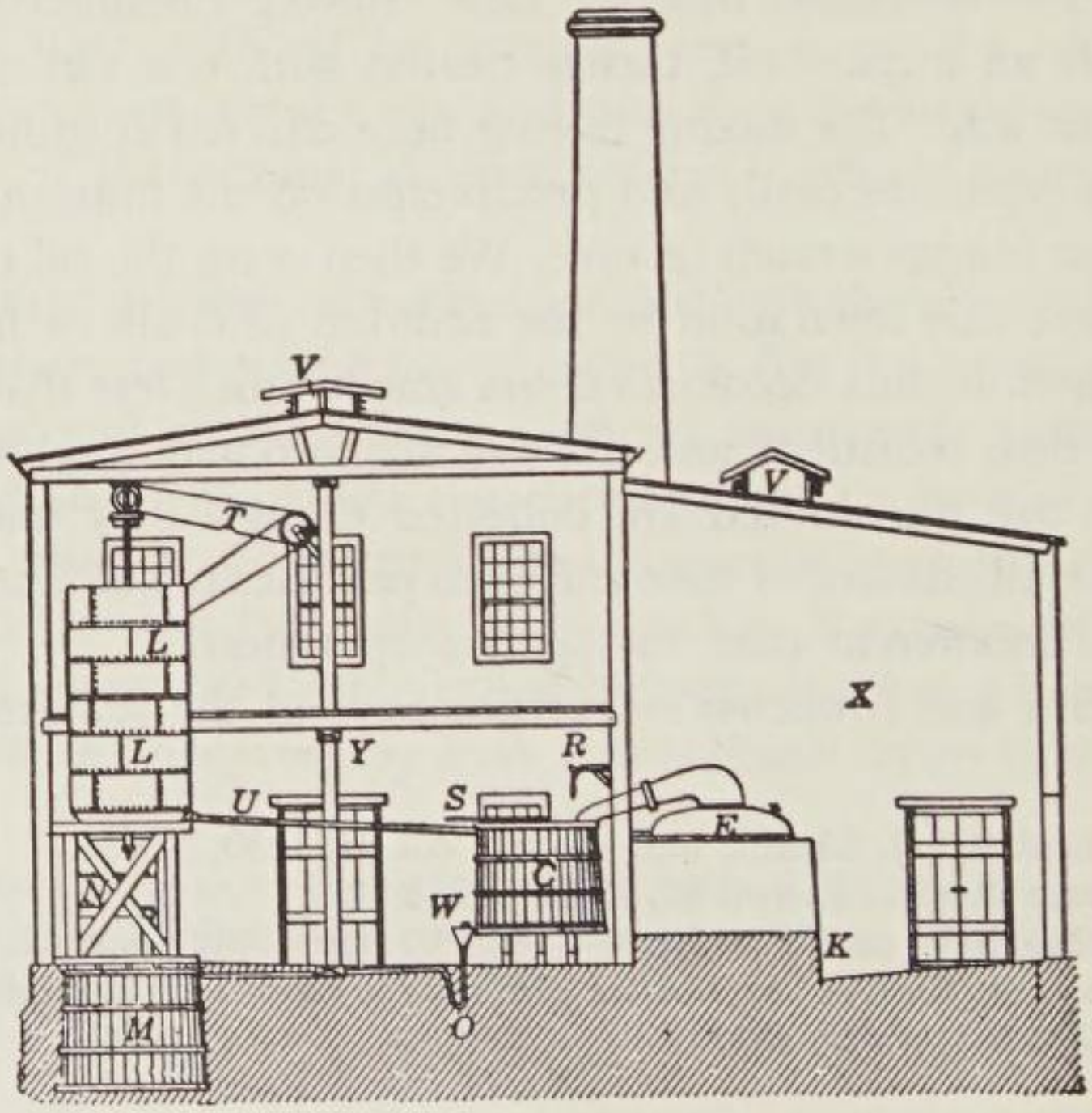


Fig. 28. The plan of an 1860 coal oil refinery, having a daily capacity of 600 gallons (After Bacon and Hamor).

of producing a mixture of gasoline and kerosene from the shale which was little suitable for burning in lamps. In 1834 they contacted the Paris engineer Alexandre François Selligue who bought their patent in order to use it together with a process of manufacturing gas which he had just patented himself. Selligue had been working with the shales of Feymoreau which underlay coal strata in a small deposit in the Vendée between Nantes and La Rochelle. The shale strata, some 30 and 40 feet thick, ressembled in many respects the Torbanite which Young used much later, but they yielded only 15% of lighter oils. Local difficulties forced Selligue to give up working at Feymoreau and he turned to the Autun shale, though it was less rich in oil and paraffin. He succeeded in perfecting the process he bought (Nov. 1836) and patented it on October 25, 1837 as well as an improved distillation process [1] "for a slow distillation of oil shale in large vessels, producing oils which smell less and which are of an entirely different nature". The shale oil obtained by careful distillation was mixed with strong sulphuric acid, the contact time (usually 24 hours) depended on the nature of the shale and agitation was repeated regularly. A vessel with a large interior surface was used in order to make the acid tar stick to it. The quantity of acid varied from 5 to 10%. The refined oil was carefully skimmed into another vessel avoiding entrainment of acid. The oil was then washed with water and all water carefully removed before slaked lime was dropped into it and an air current was used to drive off all very volatile, smelly fractions. This was the most important part of Selligue's process if one wanted to remove the most inflammable parts from the shale oil in order to manufacture a suitable lamp oil.

Thus in 1838 Selligue marketed four products:

a. a white, volatile mineral oil, specific gravity 0.77-0.82, to be used as a solvent;
b. a less volatile, yellowish mineral lamp oil, spec. grav. 0.82-0.87;
c. a mineral lubricating oil, after the separation of
d. a white paraffin wax for the manufacture of candles.

The famous French chemist August Laurent (1807-1853) was sufficiently impressed by the quality of Selligue's products to demonstrate them at a session of the Académie des Sciences of Paris on June 12, 1837.

Once the attention had been drawn to the Autun shales exploitation on a larger scale began in 1841, the first concession being granted to one Igornay, [2]

[1] French patent No. 9159 of November 14, 1838 (Descriptions des machines et procédés pour lesquels les brevets d'invention ont été pris sous le régime de la loi du 5 juillet 1844, Tome LXVIII, pp. 395-398, Paris, 1849).

[2] Chosson, De la situation de l'industrie des schistes bitumineux du bassin d'Autuu (Annales des Mines, 6e sér., Mémoires Tome XX, 1871, pp. 347-428).

and others continued the work of Blum, Moneuse and Selligue. Thus two Paris engineers, Laurens and Thomas, obtained a patent for distillation of shales with the help of superheated steam (200° C). [1] Selligue obtained a concession at Dracy-Saint-Loup in the Autun basin on November 4, 1843. Two years later he patented his process in England. [2] Products of the French shale industry were shown at the Great Exhibition of London in 1851. The jury reported [3] that "examples of paraffin wax are exhibited in the French section, which were made from paraffin obtained by distilling bituminous schist, but far more interesting specimens are sent by James Young, which seem to realize the great problem which the rare sagacity of Liebig pointed out as far back as ten years ago . . . The process by which Young obtained paraffin and oils from coal is one of great importance which has only been fully developed since the Jury made its awards."

James Young (1811-1883) [4] was a Glasgow lad, a joiner and cabinet maker by training, who enrolled as a pupil in the Mechanics' Institute. He became assistent to the famous colloid chemist, Professor Thomas Graham, who took him to University College, London in 1837 and who was instrumental in his appointment as chemist at the chemical works of James Muspratt near Liverpool. In 1843 Young became manager of the Ardwick Chemical Works of Charles Tennant at Manchester. There he became interested in refining natural petroleum oozing forth from a mineral seam in the New Deeps mine at Riddings (sometimes also called "Alfreton"). He actually manufactured illuminating and lubricating oil from it but turned his attention to the manufacture of such oils from coal because the stream of petroleum was gradually diminishing. Actually the New Deeps mine still produced some 30 tons a month in the period of 1873-1877 but it was definitely closed in 1885.

Young was not interested in so short a supply of base materials for the manufacture of lamp oil and candles and hence he studied the cannel coal of Lancashire. The "cannel coal of Boghead near Bathgate" (West Lothian, Scotland) finally became the material turned into "an oil containing paraffine (which I call paraffine oil) and from which oil I obtain paraffine". [5] Of course many deposits of bituminous shales and rocks had been noticed and described

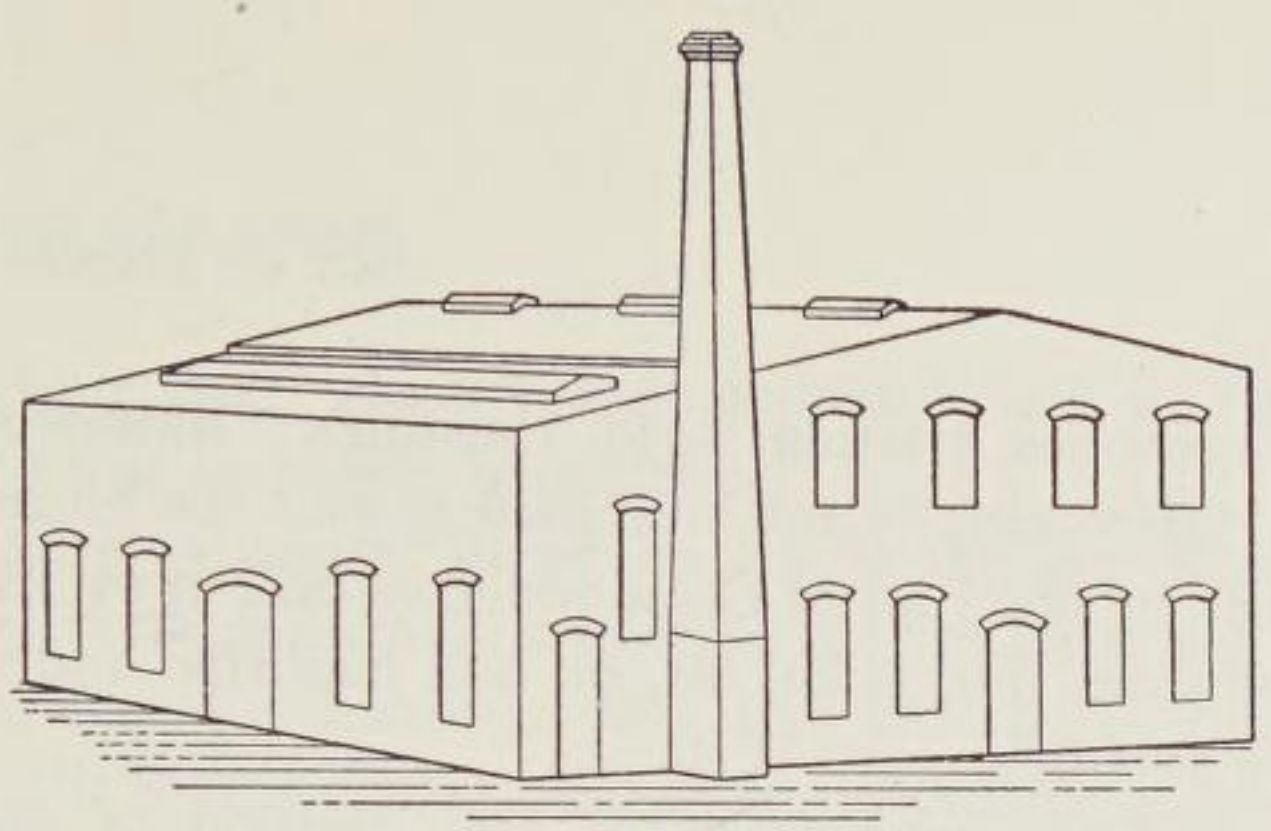
[1] French patent No. 11.831 of July 13, 1840 (Description des machines et procédés consignés dans les brevets d'invention, de perfectionnement et d'importation dont la durée est expirée, et dans ceux dont la déchance a été prononcée, Tome LXXXVI, pp. 166-168, Paris, 1856).

[2] English patent No. 10.726 of June 23, 1845 in the names of Dubuisson and Michel-Antoine Bertin-Burin.

[3] Reports by Juries, Great Exhibition, 1851 (Vol. I, p. 103; Vol. II, p. 1386).

[4] E. M. Bailey, James Young, Founder of the Mineral Oil Industry (Instit. of Petroleum Review Vol. II, 1948, pp. 180-183; 216-221, 249-252; 357-360).

[5] English patent No. 13.292 of October 17, 1850.



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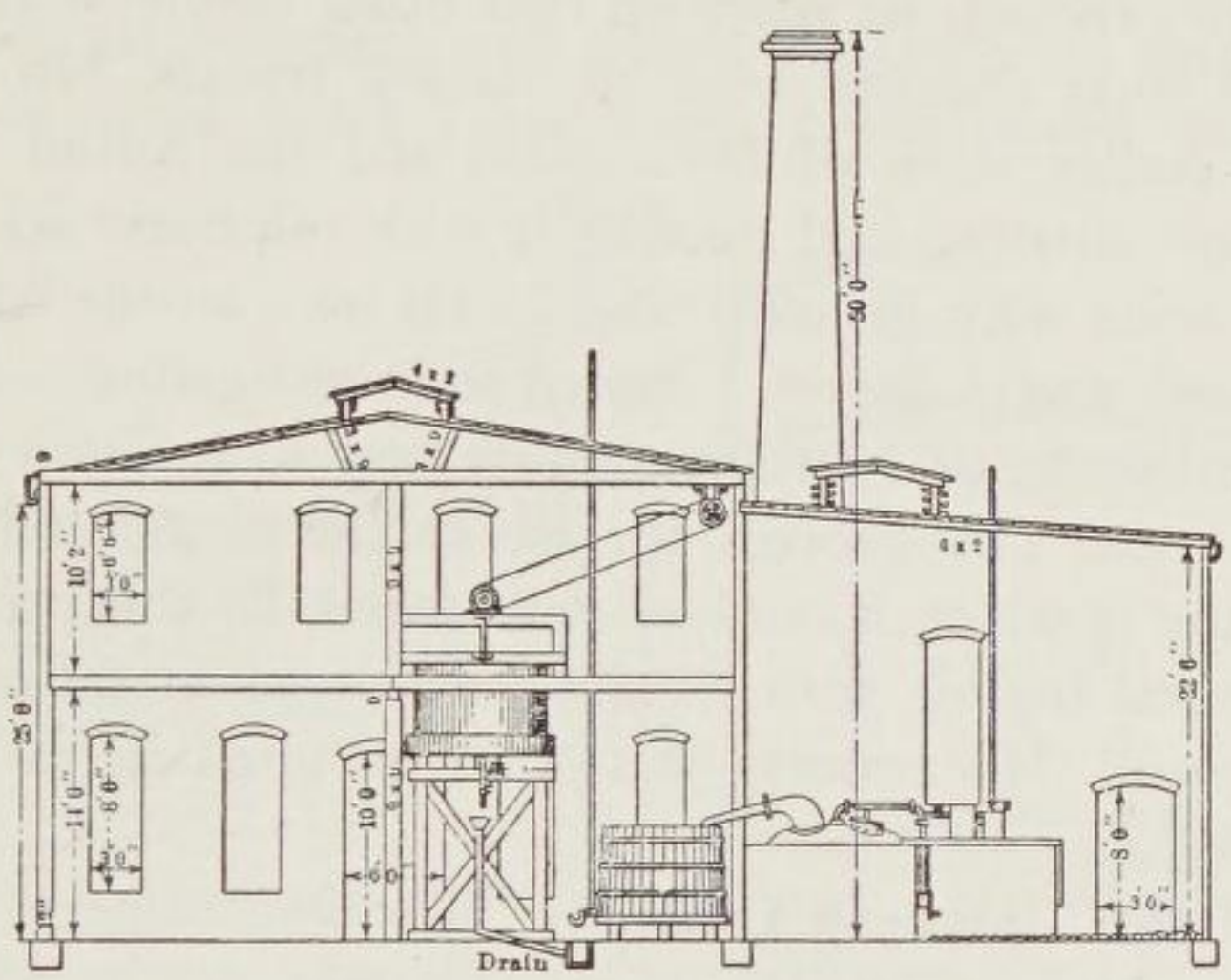

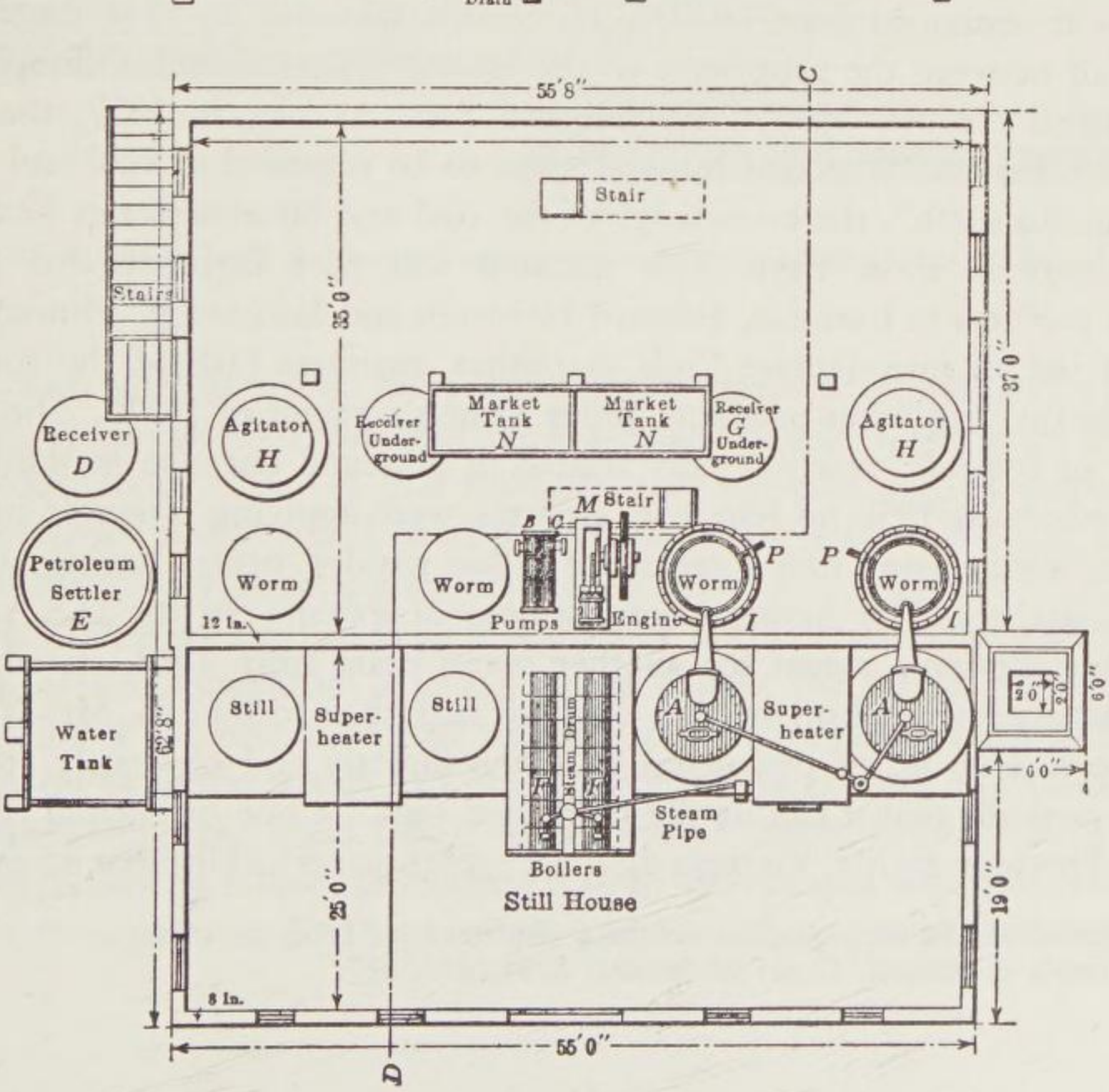

Fig. 29. A plan of the type of petroleum refinery erected in the early sixties (After Bacon and Hamor).

in Scotland for centuries starting with Jonston's "Bitumen Terrenum or Lithantrax called Pharmacitis"[1] and culminating with the bituminous deposits at Muirkirk worked by the Earl of Dundonald according to his patent of 1781 to convert this bitumen into coke, tar, oil and naphtha, and the further 150 patents granted in this field upto 1850.

James Young in his patent describes his "method of distilling coal in fragments about the size of a hen's egg, at low red heat, in a common (horizontal) gas retort", though he specified that other forms of retorts could be used and indeed soon changed over to vertical retorts. No doubt he was inspired by the earlier work of Dundonald and the Autun shale distillers in distilling the oil obtained and treating it with sulphuric acid, caustic soda and lime, but he soon went his own way. In his own words "during the time my petroleum work was going on, I started an investigation with the prospect of procuring petroleum, or substances equivalent to it, from coal, and after some time succeeded. This process consists in the distillation of coal at the lowest temperature at which it can be decomposed. By this process we obtain a mixture of several liquids with paraffine dissolved in them. This liquid I named paraffine oil". His process was soon patented in the United States too (March 23, 1852).

His choice of the "Boghead Coal" or "Torbane Mineral" was a happy one, for it contained from 60-70% of volatile material. In 1853 there arose a law-suit between the proprietor of the estate of Torbanehill, Gillespie, and the mineral tenants, Messrs. Russell and Son. At last, in 1857, the court decided [2] that the "Torbane Mineral" was to be regarded as coal and not as "bituminous earth", the knowledge of the coal and bitumen series being still rudimentary in those days. This decision was very fortunate for Young and his partners in business, Edward Meldrum and Edward W. Binney, who had set out to manufacture "oils, naphthas, manures (ash of the torbanite being meant) and other products under Young's patent of 1851". The manufacture of coal-oil" was not only started in Scotland but also in the United States where by 1858 no less than 23 firms were applying Young's patented process, some paying him 2 cents par gallon royalty, others having acquired general licenses. The Acting Commissioner of Patents for the U.S.A. when extending Young's patent for another seven years from 1864, stated: "The manufactures of coal-oil in this country had their origin in Mr. Young's discovery. The use of petroleum followed directly and obviously from the use of coal-oils that it can hardly be denied that the one originated from the other. Previous to Mr. Young's discovery, petroleum had little or no commer-

[1] J. Jonston, Thaumatographia naturalis (Amsterdam, 1665, p. 146).
[2] Gillespie v. Russell, Court of Session 1854-1856-1857.

cial value. An invention which has contributed such wonderful results can occupy no low place in public benefaction".

Young's main importance, however, lay in the fact that he was able to produce good marketable paraffin wax from his "paraffine oil". The discoverer of paraffin wax, Von Reichenbach, was the first to recognize this in 1854, when he wrote: "It is true that the discovery of paraffin is my own and I have announced it. To Mr. Young, however, belongs the merit of a second discovery, the merit of having elaborated a method which furnishes a comparatively large quantity of the substance and which is sufficiently renumerative to the manufacturer—a result which I had vainly endeavoured to realize". In fact

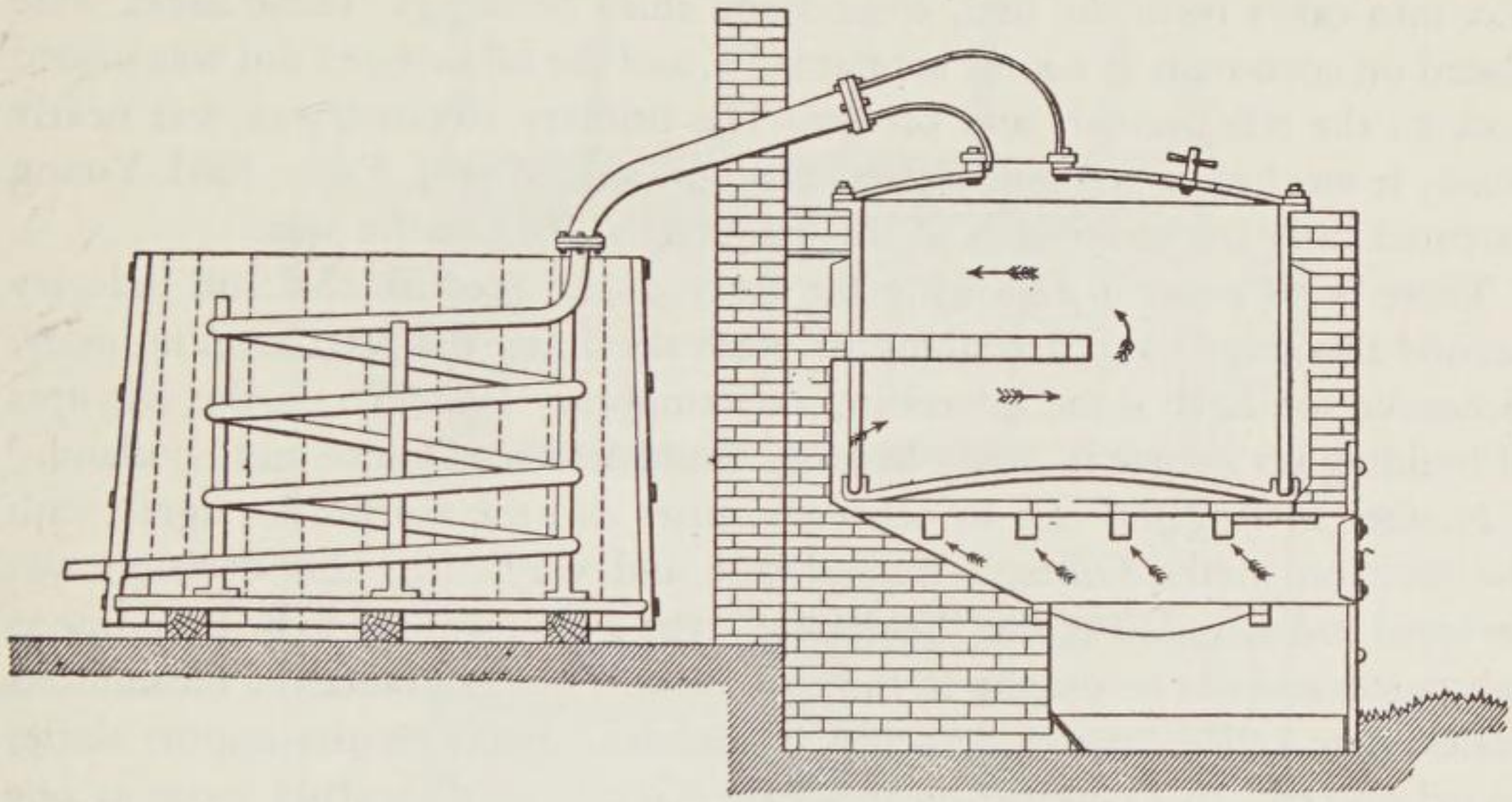

Fig. 30 Section of still and condenser, such as were used about 1865 (After Bacon and Hamor)

Young was, what we would call a chemical engineer, who could carry a process beyond the laboratory bench and the experimental still to the stage of large-scale manufacture. He "at first manufactured naphtha and lubricating oil. Paraffin oil for burning and solid paraffin were not sold until 1856, and the demand for it only became considerable in 1859".

When Young resorted to vertical retorts he also introduced steam injection to prevent decomposition of the vapours during the longer way through the contents of the retort. During the first four hours of the run he obtained ammoniacal vapours, which had been recovered by cooling and turned into ammonium-sulphate (since 1865). This product finally became the prop of the industry saving it from immediate ruin by the cheaper imported American kerosine from petroleum. The next twenty hours of the run yielded the "shale

oil", the end of the run being indicated by water turning up in the distillate. Then the retorts were unloaded and refilled. Redistillation of the shale oil gave a naphtha, a lamp oil ("photogen", about 12%), some 17% of a gasoil fraction called "solar oil", two lubricating oil fractions and about 1¼% of paraffin wax obtained from the lubricating oil by processes which were basically the same as those now current in the petroleum industry.

The crude wax obtained by refrigeration was packed in bags and submitted to high pressures in hydraulic presses. The "scale wax" thus obtained could be made oil-free with the help of solvents, and then decolorised with animal coal. Later Young introduced a sweating process, casting the crude yellow wax into cakes from the first, second and third pressings. These cakes were placed on coco-mats in rooms kept at 50° C and the oil sweated out was passed back to the refrigerators and presses. The primary sweated wax was nearly white, it was resweated and filtered through animal coal. From 1861 Young patented these improvements of the manufacture of paraffin wax.

There is no point in following the story of the Scottish shale-oil industry beyond this stage [1] and describing its gradual ruin by the petroleum industry. However, we have some interesting contemporary evidence on the attempts of building up a shale industry in other countries than France and Scotland. [2]

Neither in England nor in other countries did the authorities agree with the decision in the Gillespie-Russell case and very often this decision was reversed and materials of the "Torbanite" type were regarded to be bituminous substances and not belonging to the coal series. Thus in France the bituminous shales were called "pierre de schiste" and not subject to the import duties levied on coal. In Frankfort-on-the-Main (Germany) difficulties arose as one English firm held the local monopoly for gas manufacture from coal and another from shale, oil and other substances, coal excepted. Engelhard, who had heard of the excellent qualities of Torbanite had imported a ship's load of this mineral but the customs officers declared it to be a kind of coal and decided to levy an import duty. Experts (including the famous Von Liebig) called in to decide the matter advised the Central-Zollamt to regard this Torbanite as a bituminous shale not liable to be taxed.

In fact many countries like Germany and the United States started to import Scottish base materials of the Torbanite type until they found local minerals of this kind. In Britain the Kimmeridge shale of Dorset had been used by Evan Hopkins since 1857, but his business grew less prosperous as this shale contained much less volatile matter. In Ireland the Irish Peat Com-

[1] E. M. Bailey, The oilshales of the Lothians, 3rd edit. London 1927, pp. 340-361.
[2] W. H. de Greve, Petroleum of aardolie en haar voorkomen in Nederlandsch-Indië (Tijdschrift v. Nijverheid en Landbouw in Ned. Indië, 1865, pp. 281-356).

pany was founded in 1854 and built a factory at Athy (County Kildare), but as the peat yielded only 1½% solar oil and 1/20% paraffin wax this factory was closed as early as 1858.

In Germany, notably in the Rhine province and in Saxony, the shale oil

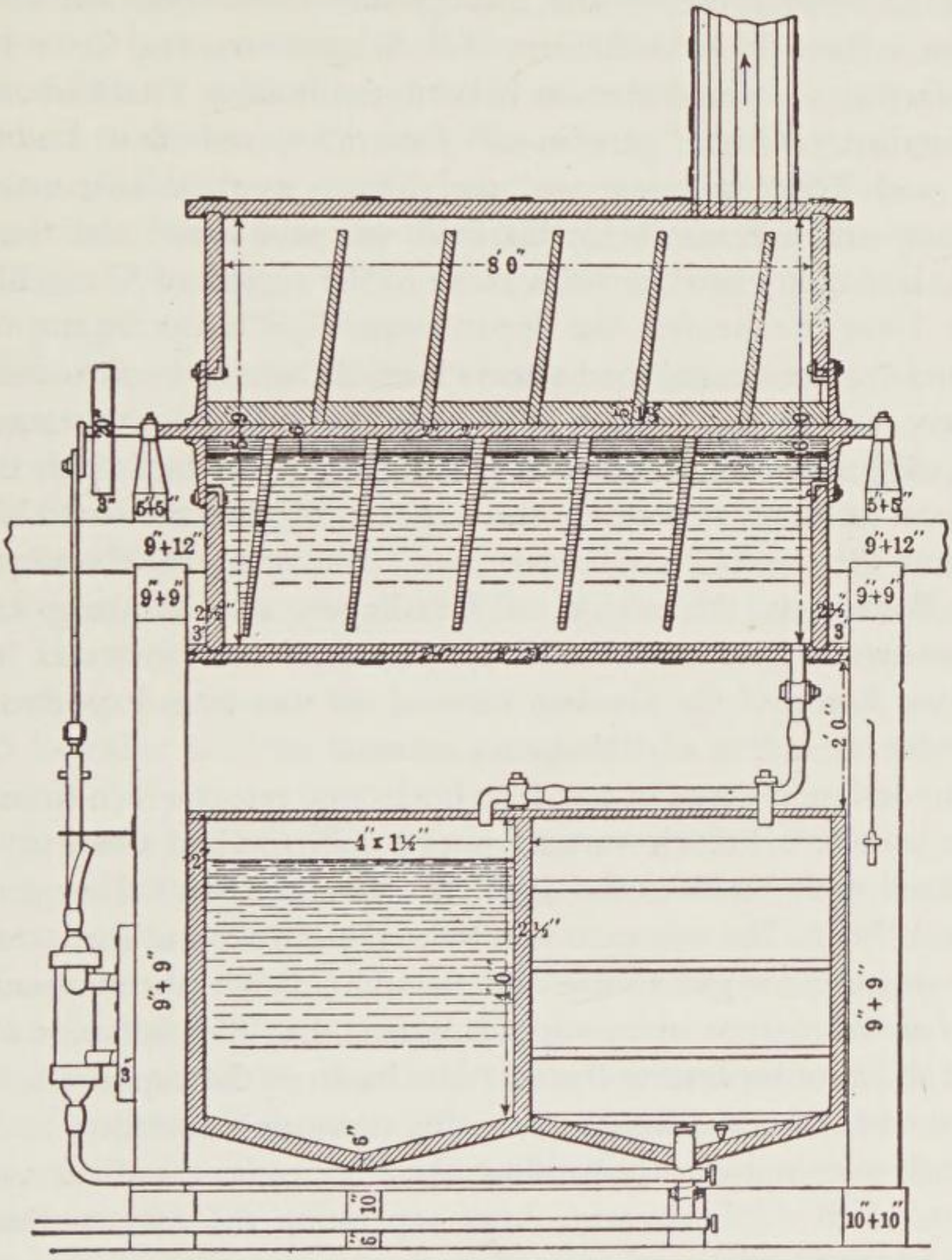

Fig. 31. The longitudinal section of a horizontal washer and tanks (1865) (After Bacon and Hamor).

industry [1] was more successful. The founder of this industry was Vohl, who was entrusted in 1849 by the "Société des schistes bitumineux du Rhin" to study the "paper-coal" (or Blatt-Schiefer) near Cologne. This shale proved to yield some 20% of tar and upto 1% of paraffin wax. A subsidiary company,

[1] P. Max Grempe, Schieferöl (Chem.-Techn. Industrie 1918, p. 1).

Wiesmann and Co., was now founded which directed the Augustenhütte at Beuel (opposite Bonn) producing mineral oils and paraffin wax from 1851 onwards.

The exploitation of the Blattschiefer quarries near Cologne, Bonn and Linz grew as more plant for the manufacture of mineral oils and paraffin wax was built there. In 1855 the firm of P. Wagenmann and Co. was founded and their factory at Neuwied soon became the leading establishment in this branch of industry. Other "paraffin-oil" factories were built at Ludwigshafen, Hamburg and Töpplitz using peat and lignite as their base-materials. By healthy competition research in this field was stimulated and this industry prospered. In Saxony new factories arose in the region of Weissenfels, Halle and Zeitz. Near Weissenfels the upper strata of a heavy lignite formation, the so-called "white lignite" had always been thrown away as useless. It now proved very valuable and from 1855 onwards yielded an average of $3\frac{1}{2}\%$ photogen, 4% solar oil and 3.15% paraffin wax, proving much richer than the usual peat or lignite treated in other regions. By 1863 the seven Weissenfels factories and the quarries employed over 1,200 men. In Württemberg and Northern Bavaria in the region of Reutlingen and Bamberg Upper-Lias shales were treated and the mineral oil produced used in street lighting in many towns. Some of the German mineral oil was even exported to Great Britain under the name of "Madden's mineral oil".

Vohl had designed a type of cast-iron horizontal retort which soon displaced the rather primitive French vertical retorts first used in Germany. In 1857 furnaces lined with chamotte bricks were introduced and these proved very efficient and cheap. The ash extracted from the retorts and furnaces was sold as a cheap manure, the gases were used for illumination, the ammonia-bearing fractions converted into ammonium-sulphate. In 1859 Schmidt solved the difficult problem of separating the tar particles from the vapours by designing a new type of condenser, which made this separation complete.

The crude oil obtained by distilling the shale was redistilled and the oils were refined with sulphuric acid. After separating the acid tar the traces of acid were removed with caustic soda solution. Creosote and aniline were prepared from the caustic solution. In 1856 Wagenmann introduced vacuum distillation of the tar and produced much better chemicals. Obtaining an improved quality paraffin wax from the crude wax, called "paraffin butter" in this industry, was first achieved by Wiesmann and Co., who separated the mineral oil from the wax by centrifuges and introduced cold and hot pressings. In 1857 Wagenmann succeeded in mixing the mineral lubricants with 1% of ricinus oil and saponifying them by heating the mixture at 120° C in vacuo, thus preparing an excellent mineral grease.

Even in the Netherlands there were attempts to produce such coal oils. The firm of Van Sonsbeek and Co. built a factory at Dedemsvaart in 1854 to produce coke from peat but it had soon to close its doors as the process proved much too expensive. Van Dam van Isselt had some success in preparing "bog oil" (veen olie) from peat dug near Amstelveen and the capital Amsterdam. However, such products from peat seldom yielded more than 2% of photogen, 3-5% of solar oil and 1/3% of paraffin wax, and such factories were doomed to a sure death with the coming of petroleum kerosine and paraffin wax. Gelderman at Oldenzaal studied the "gildenhuis kool", a bituminous shale found near the German frontier in Hanover. It was found to yield 17% of photogen, 14% of solar oil and over 1% of paraffin wax, but nothing came of its exploitation.

In the States the "coal-oil" industry had prospered for some time. American cannel coals, even the Breckenridge coal, were not as rich as the Scottish shales and their products were less easy to refine. Still this industry began to develop in Ohio from 1857 onwards and in 1859 34 factories in the United States employed 2,000 men and produced nearly 25,000 gallons of coal-oil daily. However, the end was near, when "colonel" Drake drilled the first well near Titusville and struck oil. Coal oil could not compete with the abundant, cheap petroleum oils and the industry disappeared quickly, after petroleum kerosine became available in quantities undreamt of only a few years earlier. [1]

Whale oil had already suffered from the competition of the coal oil. In 1844 635 American whalers (total tonnage some 200,000 tons) sailed out to the ice-bound seas of the North, in 1857 there were still 655 whalers with an equal tonnage but in 1861 this total had already been reduced to 514 ships with a total tonnage of 160,000 tons. They could not only blame the whales for retreating far north beyong their reach, but coal oil and petroleum had spoiled their markets. Vegetable oils no longer counted as illuminants, they were used more properly for human consumption, soap manufacture or as ingredients in paints.

The exports of petroleum kerosine [2] to Europe increased by leaps and bounds. During the first half of 1861 130,683 gallons were exported to Europe, in the same period of 1862 a total of 4,335,389 gallons and during the first six months of 1863 17,056,049 gallons had sailed to England, France, Germany,

[1] Th. Antisell, The Manufacture of Photogenic or Hydrocarbon Oils from Coal and other Bituminous Substances (New York, 1859). — Abraham Gesner, Practical Treatise on Coal, Petroleum and other distilled Oils (New York, 1861).

[2] K. F. Beaton, Dr. Gesner's kerosene (The Business History Review, March 1955, pp. 28-63).

Australia, Cuba and Holland. The price of kerosine dropped to a third between 1861 and 1862. This development meant the slow death of most shale oil industries, some of which lingered on because of the ammonium-sulphate and paraffin wax which they produced. But when about 1866 supplies of paraffin wax from American crudes began to flood European markets [1] the ammonium-sulphate remained the only prop of the industry, working with a batch process which could never compete with large scale continuous distillation of petroleum. Coal oils found their true destiny when they became the base materials of the German chemical industry.

[1] R. J. Forbes and D. R. O'Beirne, Technical Development of the Royal Dutch/Shell, 1890-1940 (Leiden, 1957).

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